Science 30

MODULE 6

Electromagnetism

Distance Learning

Alberta
EDUCATION

Science 30

Module 6

Electromagnetism

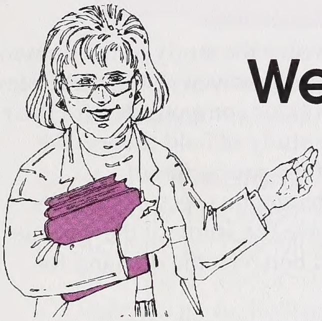
Distance Learning

Alberta
EDUCATION

This document is intended for	
Students	✓
Teachers (Science 30)	✓
Administrators	
Parents	
General Public	
Other	

Science 30
Student Module Booklet
Module 6
Electromagnetism
Alberta Distance Learning Centre
ISBN 0-7741-1173-9

Cover Photo: NASA



Welcome to Module 6!

We hope you'll enjoy your study of Electromagnetism.

To make your learning a bit easier, watch the referenced videocassettes whenever you see this icon.

You also have the option of viewing laser videodisc clips when you see this one.

When you see this icon, study the appropriate pages in your textbook.

Good Luck!

Course Overview

This course contains eight modules. Modules 1 and 2 involve the study of the human circulatory system, defence mechanisms, the nervous system, as well as the principles of genetics. Modules 3 and 4 investigate acids and bases, organic compounds, and their effects on the environment. Modules 5 and 6 involve the study of field theory, the operation of various electrical devices, as well as some of the properties of electromagnetic waves. Module 7 focuses on the electromagnetic spectrum and its relation to the study of the Universe. Module 8 will involve the study of the various sources of energy and how a balance must be maintained between the demand for energy and the need to maintain a viable environment.

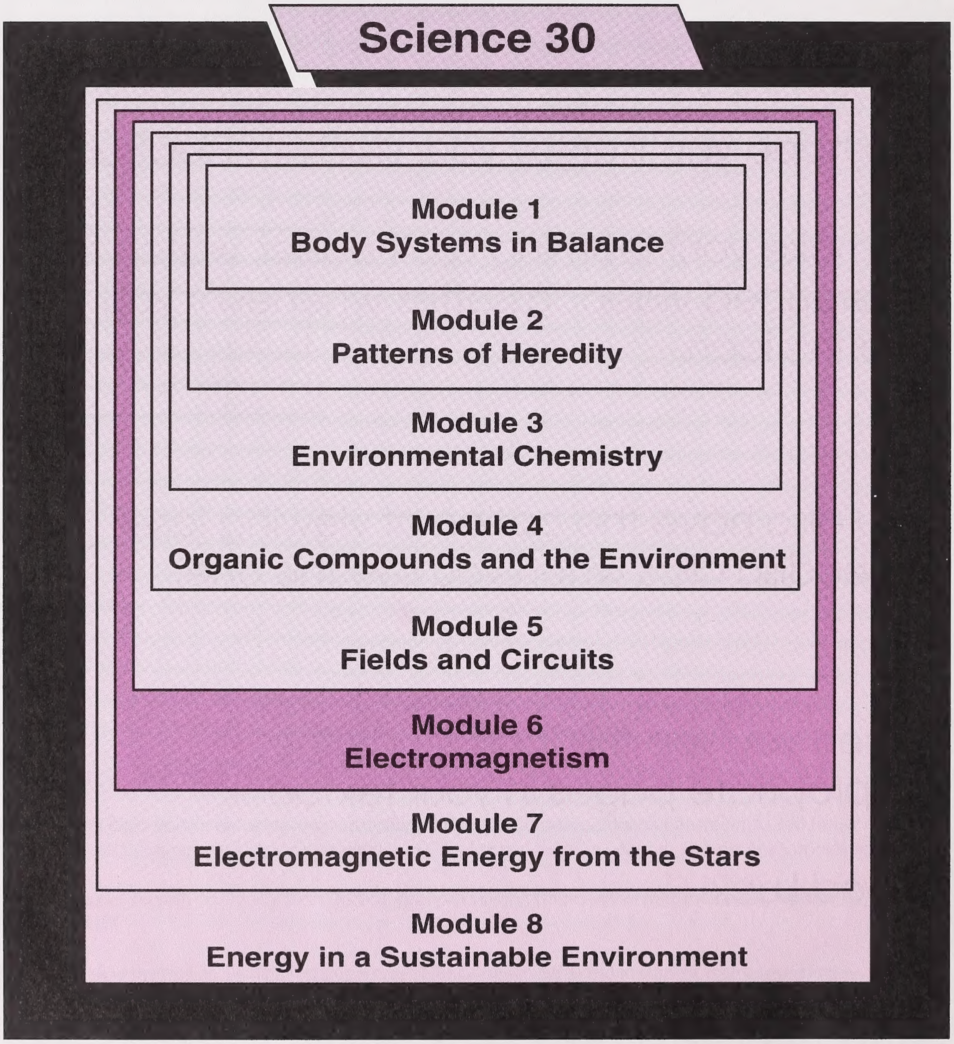


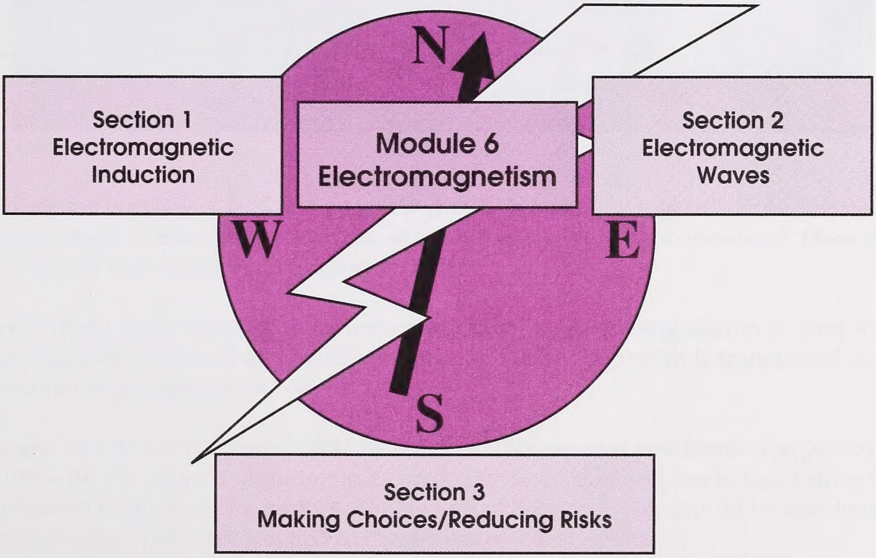
Table of Contents

MODULE OVERVIEW

You are awakened from a restless sleep by the annoying buzz of your alarm clock. You roll over and reach to hit the snooze button for another ten minutes of tossing and turning. But wait—your alarm was incorrectly set and you have less than an hour to get ready! You quickly set the microwave oven to defrost a muffin for your breakfast while you take a fast shower and blow-dry your hair. You grab your muffin and dash outside. You turn the key in the ignition of your car and are rewarded as the starter kicks in and the engine roars to life. As you pull out of the driveway, a glance at your digital watch assures you that you have just enough time.

Stop and consider how very different this scenario would have been just 100 years ago. How many of the devices that you use in your daily life are dependent on an electric power source? Microwave ovens, watches, automobiles, heating elements, radios, televisions—the list is endless! If you are like most people, you have probably not given much thought to just how dependent society is on such devices, or even how these devices work.

This module examines the principles behind electromagnetic induction and the nature and behaviour of electromagnetic radiation. You will also consider risks and benefits of one type of electromagnetic radiation.



Evaluation

Your mark in this module will be determined by how well you complete the assignments at the end of each section. You must complete all assignments. In this module, you are expected to complete three section assignments. The mark distribution is as follows:

Section 1 Assignment	**40 marks**
Section 2 Assignment	**30 marks**
Section 3 Assignment	**30 marks**
TOTAL	**100 marks**

Section

1 Electromagnetic Induction

WESTFILE INC.

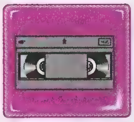
How does the burning of fuel at a generating station enable you to power household appliances such as electric fans, stereos, dishwashers, and vacuum cleaners? How does the burning of fuel result in an electric current?

Electric current flows through the wires connecting the generating station to your home. Design engineers ensure that a sufficient amount of electric current is transferred to your home from the generating station.

At the end of this section you should be able to combine what you learned in previous modules with the process of inducing a current to flow. You will apply hand rules to the operation of devices like motors. By the end of Section 1 you should be able to relate the concepts that you have learned to the design of transformers.

Activity 1: Describing Electromagnetism

In the last module, you analysed and plotted the magnetic field surrounding a permanent bar magnet. In this activity you will show the shape of magnetic fields and use hand rules to describe the magnetic fields surrounding current-carrying wires.



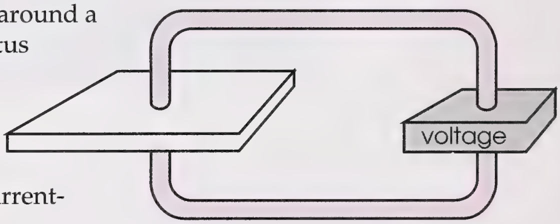
The video series called *Electromagnetism*, TVOntario, ACCESS Network, 1987, contains a ten-minute program called "Magnetism and Electron Flow." You may be able to obtain this video through your school or local library or you can purchase it from the Learning Resources Distributing Centre. Familiarize yourself with the following questions prior to watching the program. This will help you focus on the main ideas while you are viewing. You may have to periodically stop the tape in order to record your answers.

1. How are two opposite poles of magnets similar to oppositely charged objects?

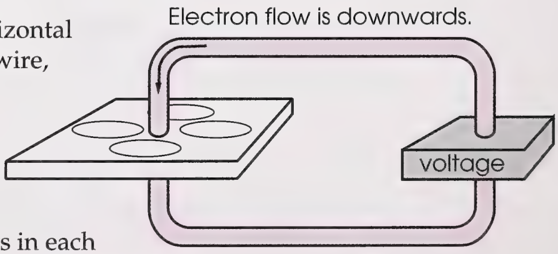
2. What did Hans Christian Oersted attempt to do through his experimentation using Volta's battery?

3. When Oersted placed a compass needle perpendicular to a conductor that was carrying electrons, there was no deflection. Describe the result when the compass needle was placed parallel to the conductor that was carrying electrons. What does this observation suggest about electricity and magnetism?

4. Ampère studied the magnetic field around a current-carrying wire using apparatus like that shown in the diagram to the right. Copy this diagram into your notebook and then complete the diagram by drawing the pattern of iron filings around the current-carrying wire.



5. When a compass is placed on a horizontal plane around the current-carrying wire, the compass needle is deflected. Copy the diagram shown to the right into your notebook and complete the diagram by drawing the direction in which the north pole of the compass points in each position. Indicate whether the direction of the magnetic field is clockwise or counterclockwise.

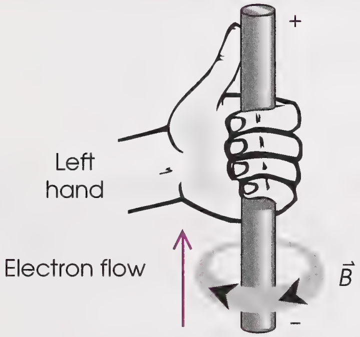


6. How does the shape and direction of the magnetic field change when the direction of electron flow is reversed?

Stop the video so that you can think about what you have just seen. The magnetic field lines that you've been dealing with circle a wire that has electrons flowing through it. These magnetic field lines have either a clockwise or counterclockwise direction, depending on the direction of electron flow. How can you remember which field direction matches which magnetic field circulation?

A convenient way to remember and predict field directions involves using your hands. Place the thumb of your left hand so that it points in the direction of electron flow. Your fingers will now encircle the conductor and point in the direction of the magnetic field lines. This is called the **left-hand rule for conductors**.

left-hand rule for conductors – a rule that shows the direction of the magnetic field around a conductor using electron flow



The magnetic field around the conductor is clockwise when viewed from the top.

Now you should be ready to return to the videocassette. Familiarize yourself with the remaining questions prior to watching the program. As you watch the tape, try using the hand rules to confirm directions whenever the rules are used on the screen. It is very important that you master the use of the hand rules; so if something doesn't work out, stop the tape, return to these explanations, and try again.

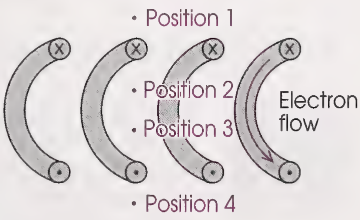
7. Use diagrams to illustrate that the reversal of current in a conductor results in the reversal in the direction of the magnetic field.

8. When current flows through a conductor, a magnetic field is set up around the conductor. Describe the result of opening a switch in a circuit in terms of $\vec{B}$.

9. When working with a helix (coil) that consists of a series of loops, the symbols ⊙ and ⊗ are used. What do these symbols represent?

10. This diagram represents the side view of an **electromagnet** with electron flow through the coils. Copy this diagram into your notebook and use the appropriate hand rule to indicate the direction of the magnetic field at positions 1, 2, 3, and 4.

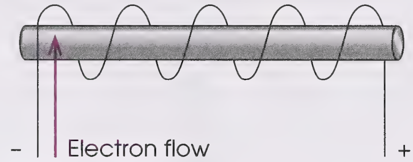
electromagnet – a series of current-carrying coils that produces a magnetic field similar to a bar magnet



11. Briefly explain why the magnetic field strength is stronger inside the coils than outside.

left-hand rule for coils – a rule that shows the direction of the magnetic field inside a coil that is passing a flow of electrons

12. The **left-hand rule for coils** is used to predict the direction of the magnetic field produced by a coil or electromagnet. It states that the fingers point in the direction of the electron flow and the thumb points in the direction of the magnetic field **inside** the solenoid. Apply this rule to show the north and south poles of the electromagnet that is shown.



Stop the videocassette at the end of the program.

Check your answers by turning to the Appendix, Section 1: Activity 1.

13. Copy the following headings into your notebook. Be careful to adjust the space under each heading to accommodate your answers. Complete the chart by indicating two similarities and two differences between permanent bar magnets and electromagnets.

COMPARING PERMANENT BAR MAGNETS TO ELECTROMAGNETS	
Two Similarities	**Two Differences**

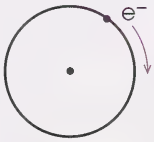
Check your answers by turning to the Appendix, Section 1: Activity 1.

In the next part of this activity you will investigate magnetism at the atomic level.

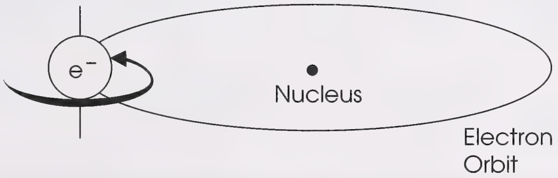
The video series called *Electromagnetism* contains a ten-minute program called "Domain Theory." You may be able to obtain this video through your school or local library or you can purchase it from the Learning Resources Distributing Centre. Familiarize yourself with the following questions prior to watching the program. This will help you focus on the main ideas while you are viewing. You may have to periodically stop the tape in order to record your answers.

14. Describe what happens when an iron core is inserted into the coils of an electromagnet.

15. The movement of electrons around the nucleus of an atom is similar to electron flow in a coil. Copy the diagram to the right into your notebook. Use the left-hand rule to indicate the direction of the north pole of the magnetic field in the diagram.



16. The electron spinning on its axis generates a second magnetic field. Copy the following diagram into your notebook. Use the left-hand rule to indicate the direction of the north pole of the magnetic field of the electron spinning on its axis.



17. Why are most materials not magnetic?

18. Why does iron display a net magnetic field?

19. Name the three ferromagnetic substances that display a net magnetic field.

20. The atoms of ferromagnetic substances are said to be magnetic dipoles consisting of two poles—a north pole and a south pole. What is an alternative way to describe the magnetic dipoles?

21. What is the name given to a cluster of dipoles that point in the same direction?

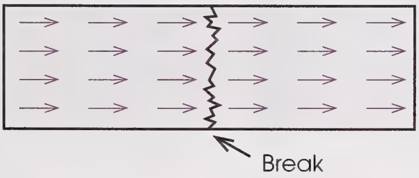
22. Explain why the magnetic field strength is increased when an iron bar is inserted into the coils of an electromagnet.

domains – groups of neighbouring atoms that produce magnetic fields that align in the same direction

23. Describe the alignment of the **domains** of the iron bar within the core of the electromagnet when current no longer flows through the electromagnet.

24. What substance is added to iron to prevent the domains from going in various directions?

25. Copy the following diagram into your notebook. Imagine that this permanent bar magnet is broken. Indicate the poles on both pieces.



26. Name two ways of destroying a permanent bar magnet.

Stop the videocassette when the program ends.

Check your answers by turning to the Appendix, Section 1: Activity 1.

Visions

The hand rules presented in the video programs will form the basis of much of your future work with motors and transformers. Because it's important to have a thorough understanding of these things, it's a good idea to consider how your textbook explains these things. Read pages 273 and 274 of your textbook and answer the following questions.

27. Identify some of the technological devices that use the principles described by the hand rules that you've been learning.

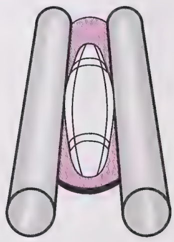
28. Explain the thinking that led André Ampère to think that two current-carrying wires could exert forces on each other.

Check your answers by turning to the Appendix, Section 1: Activity 1.

Ampère's experiment is best understood if you can see it in action yourself. The next video program contains excellent animation sequences that should really help you to understand what Ampère did.

The video series *Electromagnetism*, TVOntario, ACCESS Network, contains a ten-minute program called "The Motor Principle." You may be able to obtain this video through your school or local library or you can purchase it from the Learning Resources Distributing Centre. Familiarize yourself with the following questions prior to watching the program. This will help you to focus on the main ideas while you are viewing. You may have to periodically stop the tape in order to record your answers. You should also practise the hand rule by holding up your hand to the TV screen to be sure that you understand how this new rule works.

29. This diagram shows a device that could be used to launch projectiles.



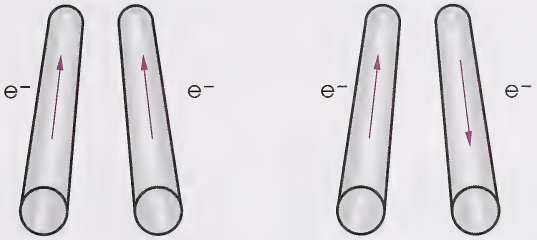
   a. What is this device called?

   b. What must occur within the rails for this device to work?

   c. Is the projectile an insulator or conductor?

   d. Why must the rails be securely anchored to the ground?

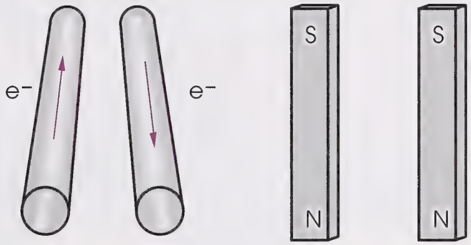
30. In 1820, Ampère made a discovery about two parallel wires when they each carry a flow of electrons.



a. What happens to the wires when the electrons flow in the same direction in both wires?

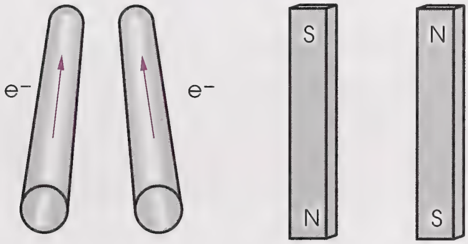
b. What happens to the wires when the electrons flow in opposite directions in the wires?

c. Copy the following diagrams into your notebook. Be sure to leave enough space to record your answers. Complete the diagrams in your notebook by drawing the pattern of magnetic field lines for each.



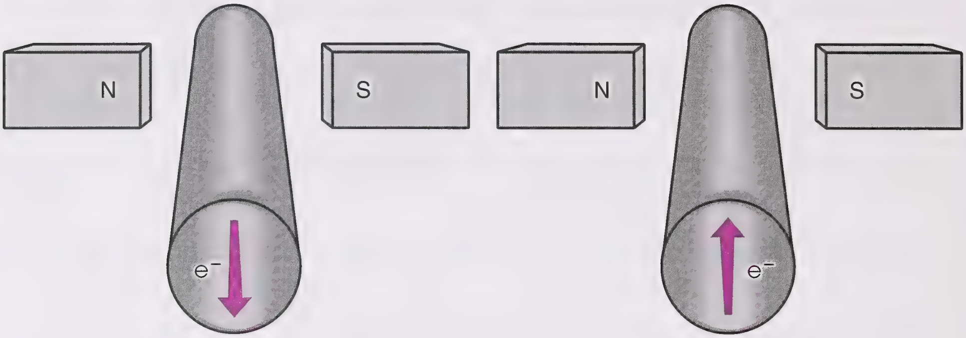
d. Describe the similarity between the patterns of field lines on the diagrams you just drew. What do the field lines suggest about the forces in each case?

e. Copy the following diagrams into your notebook. Be sure to leave enough space to record your answers. Complete the diagrams in your notebook by drawing the pattern of magnetic field lines for each.

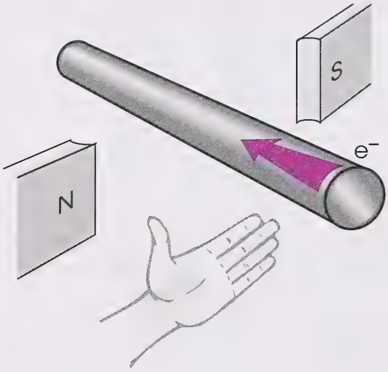


f. Describe the similarity between the patterns of field lines on the diagrams you just drew. What do the field lines suggest about the forces for each?

31. Copy the following diagrams into your notebook. Be sure to leave enough space to record your answers. Complete the diagrams in your notebook by drawing the patterns of magnetic field lines and the direction of the magnetic force in each.



32. Copy the following diagram into your notebook. Be sure to leave enough space to record your answers. Complete the diagram by drawing arrows and writing labels for the magnetic field $\left(\vec{B}\right)$ and the magnetic force $\left(\vec{F}_{m}\right)$.



motor principle – a magnetic force is exerted on a current-carrying wire that is placed at right angles to a magnetic field

33. Why is this hand rule often referred to as the **motor principle**?

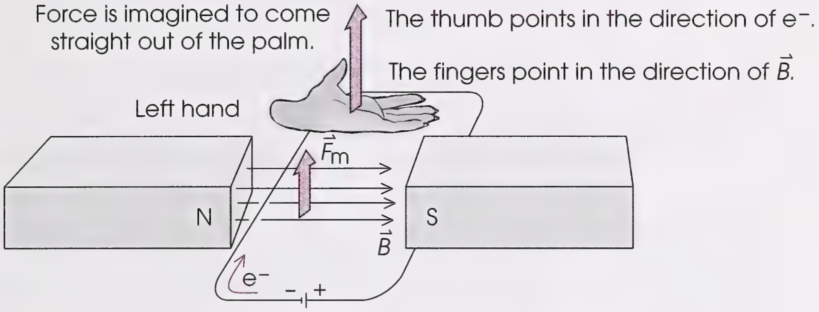
Stop the videocassette when the program ends.

Check your answers by turning to the Appendix, Section 1: Activity 1.

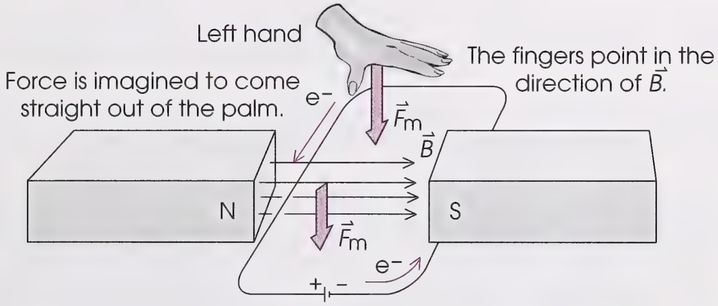
left-hand rule for force – a rule that shows the direction of the magnetic force acting on negative charges moving perpendicularly through magnetic field

Ampère's discovery that magnets can exert forces on wires that are carrying a flow of electrons provides another example of a phenomenon that requires a hand rule to describe the directions involved. Unlike the hand rule for conductors and the hand rule for coils, this one requires your fingers to be held flat instead of curled. The following examples illustrate how the **left-hand rule for force** would be properly applied.

Example 1



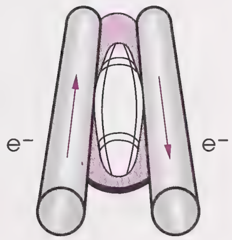
Example 2



It is important to note that this hand rule forces you to keep $\vec{B}$, $\vec{F}_m$, and the direction of electron flow perpendicular to each other.

Although the video program that you just watched had very helpful computer graphics, it did not provide a really clear explanation of how a rail gun works. Now that you know the hand rules for force, you can put together a better explanation.

34. Copy the following diagram into your notebook. Be sure to leave enough space to record your answers. Complete the diagram by drawing and labelling the magnetic field lines between the rails.



35. The projectile itself is a conductor which conducts the flow of electrons from the left rail to the right rail. Add this to your diagram.

36. You should now be able to determine the direction of the magnetic force on the projectile by using a hand rule. Remember the following key ideas as you determine the direction of the magnetic force:

    - The flow of electrons is from left to right through the projectile.
    - The magnetic field is directed vertically up through the projectile.

Check your answers by turning to the Appendix, Section 1: Activity 1.

The video programs have given you an understanding of the three hand rules that describe the interaction between electricity and magnetism. These hand rules will become powerful tools for the rest of the section as you build a simple electric motor and as you probe transformer design.

Activity 2: The Motor Effect

Why do you think electricity is used to run so many different types of appliances? How many other devices that use electricity can you think of?

PHOTO SEARCH LTD.

Part of the reason has to do with the fact that electricity can be converted into other forms of energy relatively easily. The theory that describes the conversion of electrical energy into mechanical energy is based primarily on the hand rules that you learned in the previous activity.

In the next investigation you will have a chance to build and test a simple device for converting electric energy into mechanical energy.

Science Skills

- [ ] A. Initiating
- [ ] B. Collecting
- [x] C. Organizing
- [x] D. Analysing
- [ ] E. Synthesizing
- [ ] F. Evaluating

Investigation: Building an Electric Motor

Purpose

In this investigation you will use simple materials to create a small electric motor. You will fine-tune this motor so that it operates smoothly.

Materials

You will need the following materials for this investigation:

- a felt pen or other cylindrical object with a diameter of about 1 cm
- 50 cm of enamelled magnet wire (28 gauge)
- two steel paper clips
- small piece of fine sandpaper (220 grit): 5 cm × 5 cm
- two pieces of masking tape: 18 mm × 50 mm
- 30 Ω power resistor: 5 W power handling
- DC power supply capable of 12 V output
- three connecting wires with alligator clips at each end
- bar magnet

Important Safety Precautions

Caution

It is very important that you read and apply the information in these safety warnings before you begin this investigation. Injury or death can occur even with low voltages and low currents.

- Never ground yourself while working with a live circuit. Do not touch objects, such as metal pipes, electric outlets, and light fixtures, that might be grounded. Be sure to keep your body insulated by keeping your hands and body dry and by wearing dry clothing and running shoes.

- Only replace the fuse inside the meter with the specified or approved equivalent fuse.

- Use the meter only as specified in the investigation. Do not use the meter to test a wall outlet or an electric appliance. If you try to measure a voltage that exceeds the limits of the meter, you may damage the meter and expose yourself to a serious electric shock.

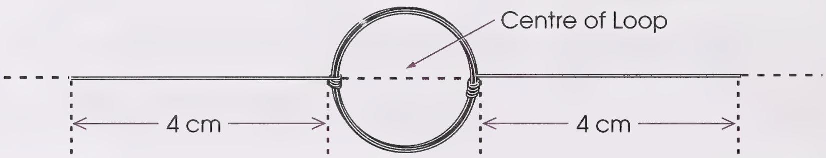
- Resistors can become warm and in some cases hot enough to cause burns. Always disconnect a recently used resistor and allow it to cool for a few minutes before handling.

You will ensure your own safety by applying this information as you complete the investigation.

Procedure

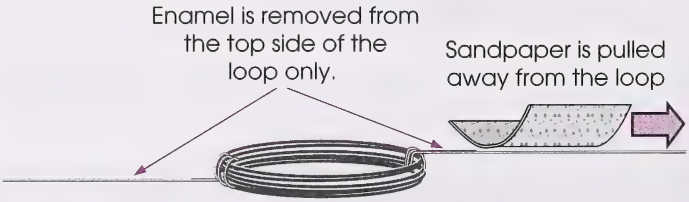
- Leaving about 8 cm of wire free, wrap the wire around the felt pen to create a tiny coil such that only about 8 cm remains free at each end.

- Carefully remove the coil from the pen and use the free ends of the wire to wrap the bundles of wire at opposite ends of the coil. This is shown in the following illustration.



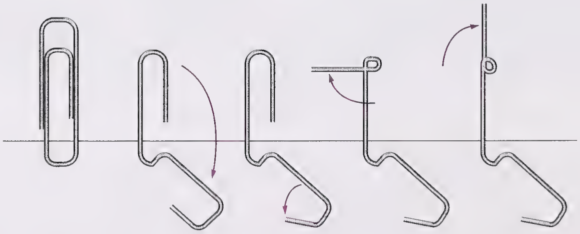
- Adjust the position of the two free ends so that they form part of a straight line that passes through the centre of the loop. Cut the free ends so that they are only about 4 cm long.

- Remove the enamel from one side of the ends of the loop with sand paper as shown in the following diagram.

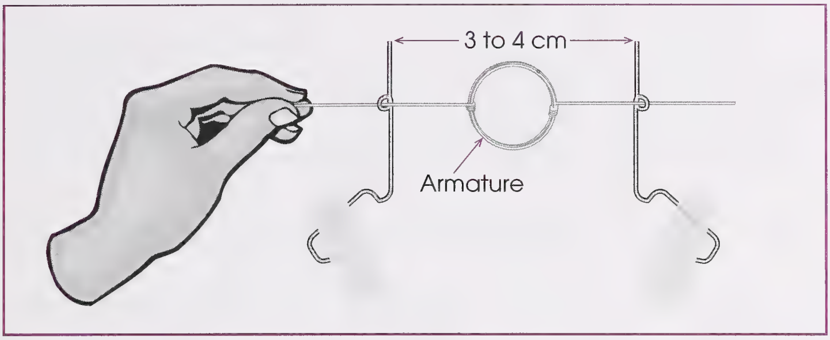


- Restraighten the free ends and adjust them if the previous step introduced bends.

- Shape each of the paper clips as shown by the steps in the following diagram.



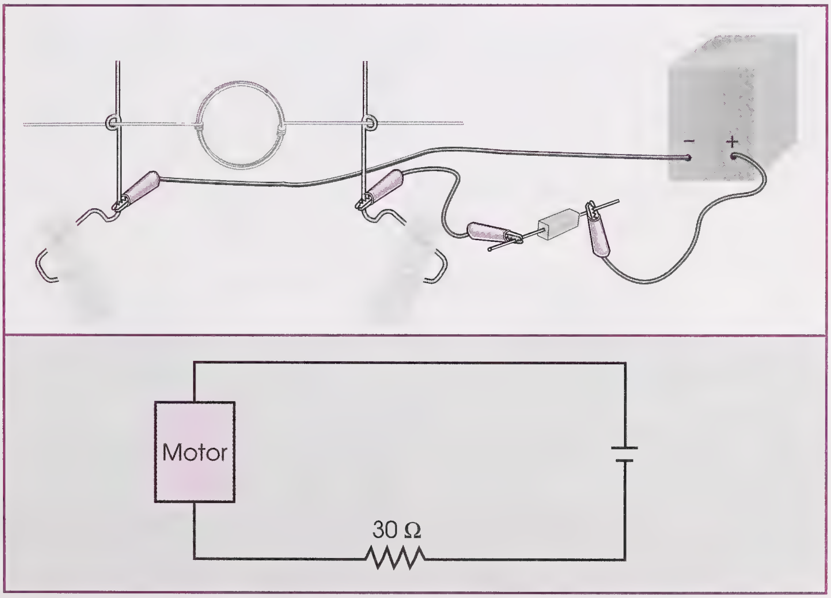
- Position the coil in the two paper clip stands as shown in the following diagram. The base of the paper clips should be taped down near the edge of a table. The loop will be referred to as the armature for the rest of the investigation.



- Use your index finger and thumb to gently cause the armature to twirl on the axis provided by the free ends.

- Adjust the free ends of the armature so that it turns smoothly without wobbles. Take your time and do this step carefully because the success of this motor depends very much on the armature being balanced on the free ends which should be as straight as possible.

- Without turning on the power supply, construct the circuit shown in the following drawing and schematic diagram.



- Hold a bar magnet horizontally as close to the armature as possible and turn on the power supply. Use your thumb and index finger to gently spin the armature on its axis. The loop should continue to spin.

- If your armature stops turning you can fine-tune your motor by trying the following adjustments:
  - Make sure that the ends of the armature are straight and centred.
  - Try spinning the armature in the opposite direction.
  - Make sure that a voltage exists across the paper clips. You may need to use a voltmeter or multimeter to test this.
  - Move the magnet to a new position. Hold one of the poles near the loop.
  - Shift the armature slightly to the left or right to change its relative position between the paper clips.
- Be observant and resourceful as you find the combination of adjustments that allows your motor to run smoothly.
- Once you have the armature running smoothly, you might try reversing poles, adding a second magnet, and placing one pole of a magnet on one side and another pole on the other side. Record what you observe.

Observations

1. a. How does the speed of the armature change if the bar magnet is moved as close as possible to the armature?

   b. How does the speed change if you add a second magnet? Why?

   c. Which poles of the magnets do you have to have together if you have the magnets on the same side of the armature?

   d. Which poles must be together if you hold the magnets on opposite sides of the armature?

Conclusions

2. What was the most important adjustment that you had to make to ensure that your motor ran continuously?

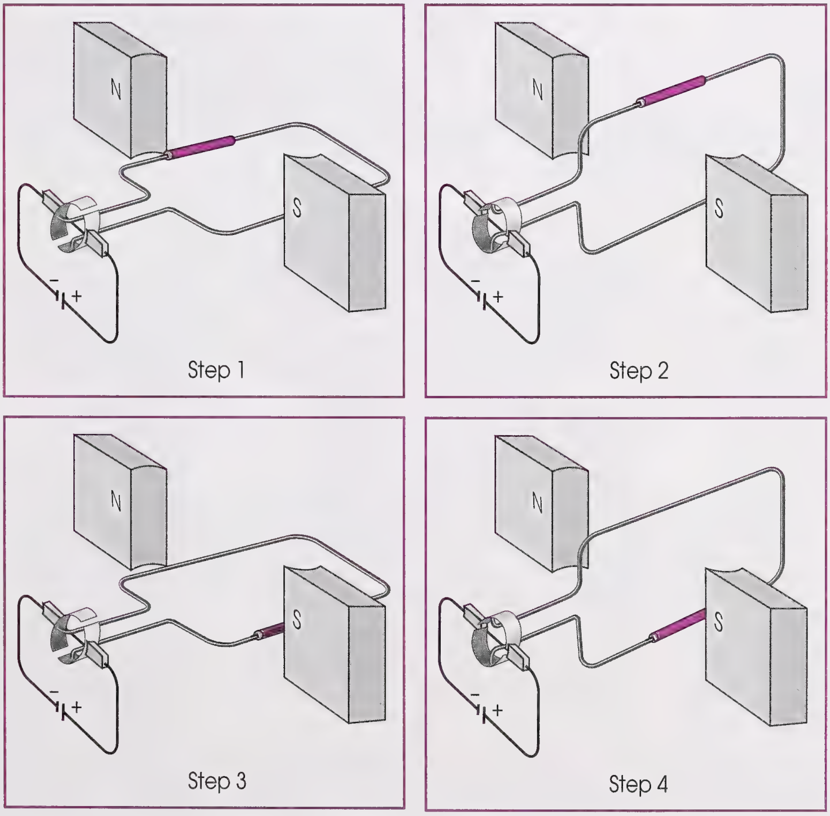
Check your answers by turning to the Appendix, Section 1: Activity 2.

Why does the loop in your motor turn? One way to begin to answer this question is to return to the program called "The Motor Principle" from the video series called *Electromagnetism*. Although you've already watched this ten-minute program, the last few minutes have a valuable computer animation sequence which shows how an electric motor works. You should watch this sequence again and look for similarities and differences between the operation of the animated electric motor and the one that you just built.

3. How is the design of the animated electric motor similar to that of your motor?

4. One essential design feature is the presence of the **split-ring commutator** and the **brushes** in a commercial electric motor. What function do these parts serve in the electric motor? What design feature of your motor did the task of the split-ring commutator?

5. The following diagrams shows steps in the operation of a simplified electric motor. Note that one part of the rotating loop has been made thicker and is coloured so that you can identify it.

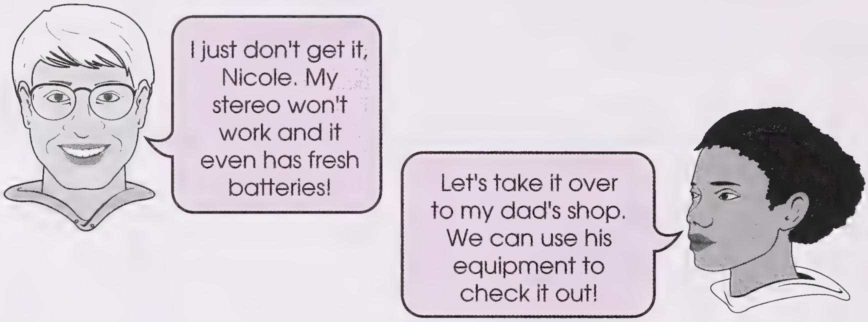


   a. Describe the direction of the magnetic force on the thicker part of the loop in each step. Refer to a hand rule to support each answer.

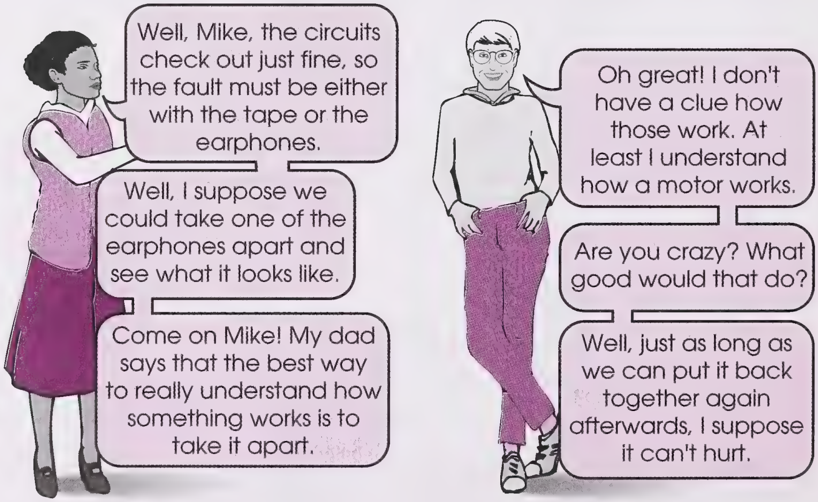
b. Explain how your answers to question 5. a. relate to the motion of the loop.

Check your answers by turning to the Appendix, Section 1: Activity 2.

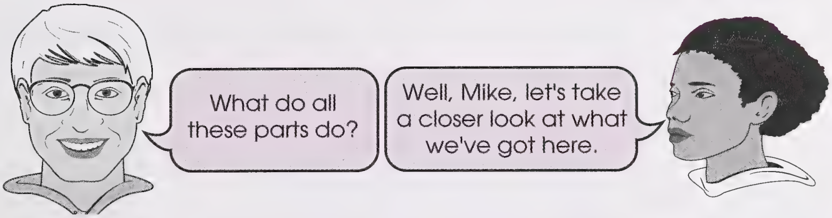
The principles behind electric motors can be applied to other devices as well. As the following conversation indicates, sometimes if you're able to take something apart you can figure out how it works.

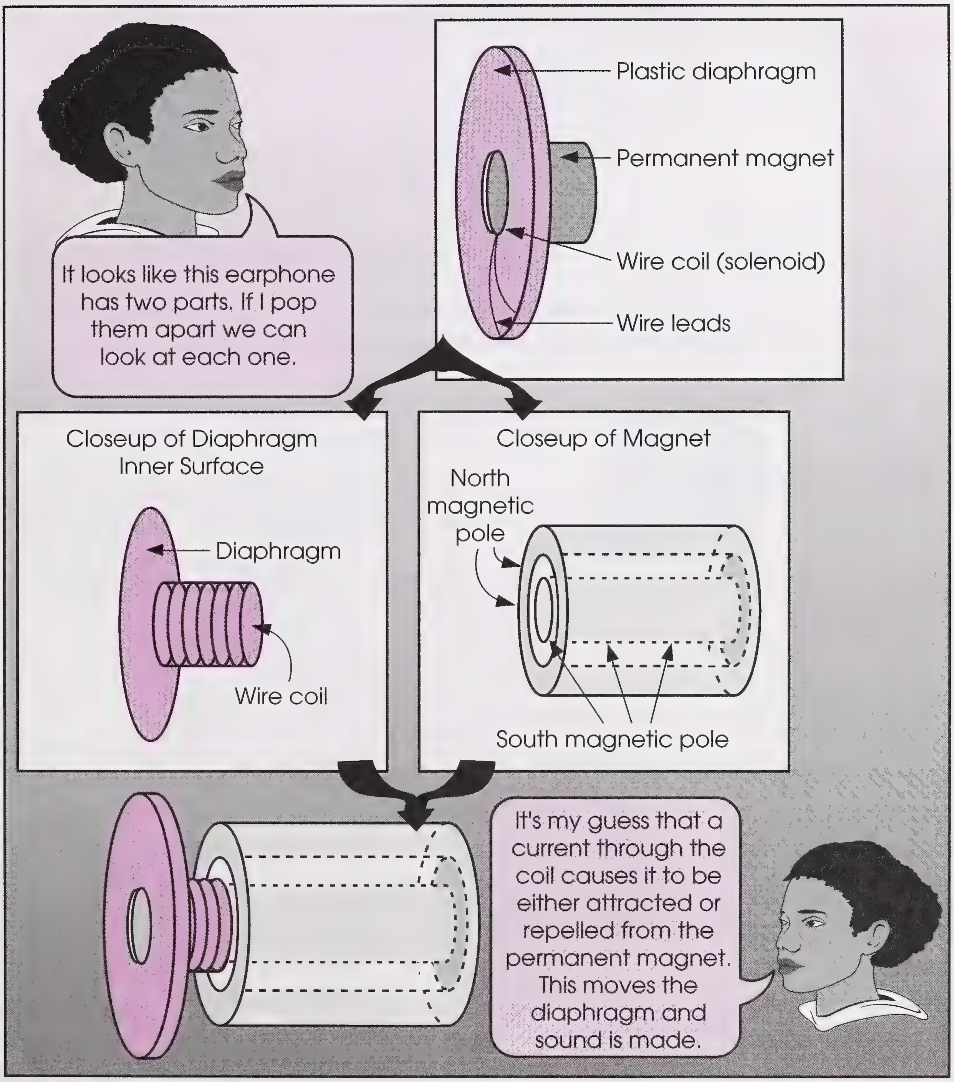


A little later on...

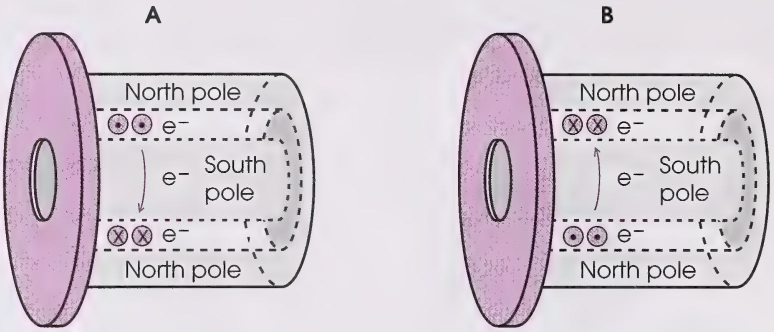


After a few tense moments, Nicole finishes taking apart the earphone and lays the pieces out on the tabletop.


What do all these parts do?
Well, Mike, let's take a closer look at what we've got here.


It looks like this earphone has two parts. If I pop them apart we can look at each one.
Plastic diaphragm
Permanent magnet
Wire coil (solenoid)
Wire leads
Closeup of Diaphragm Inner Surface
Diaphragm
Wire coil
Closeup of Magnet
North magnetic pole
South magnetic pole
It's my guess that a current through the coil causes it to be either attracted or repelled from the permanent magnet. This moves the diaphragm and sound is made.

The following questions will allow you to expand on Nicole's idea of how the earphone works. Use the concepts that you've learned and the following diagrams to answer these questions.

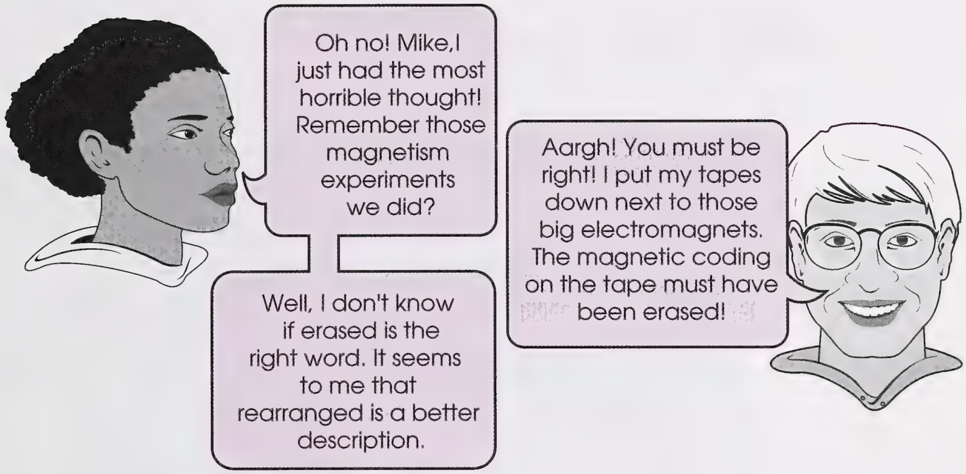


Note that the symbol e^- and the arrows refer to electron flow. Recall that the symbol ⊙ means current is moving towards you and ⊗ means current is moving away.

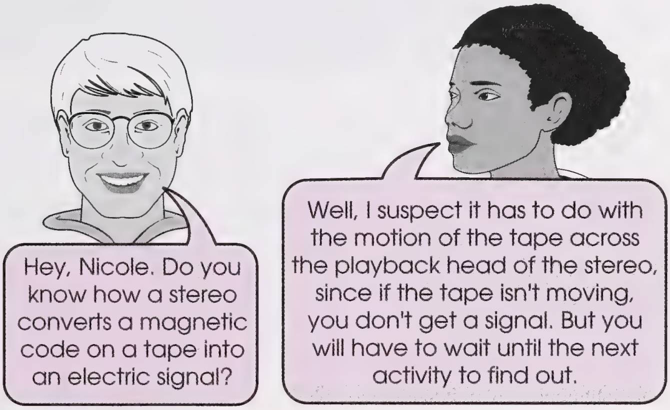
6. Refer to Diagram A. Will the diaphragm be pulled towards the magnet or pushed out? Support your answer with the appropriate hand rule.

7. Refer to Diagram B. Will the diaphragm be pulled towards the magnet or pushed out? Support your answer with the appropriate hand rule.

8. Imagine that the current in the coil begins flowing as shown in Diagram A. The current then switches directions and flows as shown in Diagram B. Finally, the current switches back and flows in the original direction. If this process repeats itself 250 times per second, describe the sound that would be produced.



9. Which term is more correct for describing the condition of Mike's tape in a physics sense, *erased* or *rearranged*? Use ideas from Module 5 to explain why you chose the answer that you did. You should note that the audiocassette is coated with a metal oxide.



Check your answers by turning to the Appendix, Section 1: Activity 2.

In this activity you've seen how the motor principle can be used to create mechanical energy from an electric current. In the next activity you'll explore the reverse process of creating an electric current from mechanical energy.

Activity 3: Inducing Electric Current

Do you enjoy listening to music on a portable stereo cassette player?

If you do, then you already know that batteries are expensive and that it doesn't take very long for them to wear out. One solution to this problem is to use an AC adaptor so that the cassette player can operate on the electricity from a wall outlet instead of batteries. Of course the electricity is not free (someone pays the bill!), but it is less expensive than buying batteries.

Have you ever wondered how the electricity for the wall outlet is created and transported to the place you use it? Equally intriguing is the question of how the cassette player that normally requires 9 V from batteries can be plugged into a 120 V outlet.

In this activity you'll answer both of these questions. The best place to begin is with the generation of electricity itself.

Science Skills

- [ ] A. Initiating
- [ ] B. Collecting
- [x] C. Organizing
- [x] D. Analysing
- [ ] E. Synthesizing
- [ ] F. Evaluating

Investigation: Generating Electricity

Purpose

In this investigation you will produce a small electric current by using the same principles that govern most electric generators.

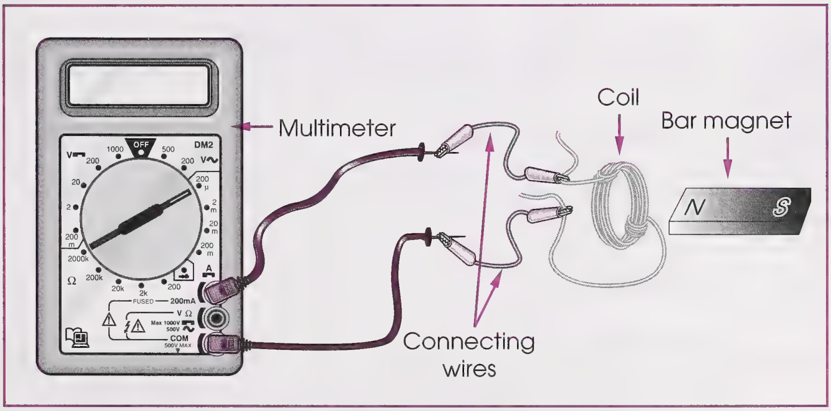
Materials

You will need the following materials for this investigation:

- 7 m of 28 gauge enamelled magnet wire
- a sensitive galvanometer (µA) or a multimeter with a microampere scale for DC current measurements
- two connecting wires with alligator clips at both ends
- a strong bar magnet

Procedure

- Wrap the magnet wire into a small coil. The coil you create should have an internal diameter large enough to allow the bar magnet to pass through. One suggestion would be to wrap the wire around a felt pen or a test tube that was slightly larger than the bar magnet.
- Use tape to secure the coil so that it does not unravel.
- Attach the loop to the galvanometer or multimeter as shown in the following diagram.



- Carefully watch the current reading as you quickly thrust the north end of the magnet into the coil.

1. Describe how the reading changed. You may need to repeat this several times to get an accurate description.

- Insert the north end of the magnet into the coil and leave it there.

2. Describe the current reading as the magnet sits motionless within the coil.

   • Check to make sure that the north end of the bar magnet is still inside the coil. Carefully watch the current reading as you quickly remove the north end of the magnet from the coil.

3. Describe the current reading as you quickly remove the bar magnet from within the coil. You may need to repeat this several times to get an accurate description.

Conclusions

4. Describe the circumstances in which a current reading was observed. Answer in terms of the magnet's motion and in terms of the magnetic field within the coil.

Check your answers by turning to the Appendix, Section 1: Activity 3.

In the previous investigation you used the motion of a magnet to create a changing magnetic field. When the magnetic field within the coil changed, a current was induced.

There is another way to observe this same effect without using a magnet. Because the important thing is the changing magnetic field, it should be possible to create an induced current without using a magnet. You'll test this idea in the next investigation.

Science Skills
- [ ] A. Initiating
- [ ] B. Collecting
- [x] C. Organizing
- [x] D. Analysing
- [ ] E. Synthesizing
- [ ] F. Evaluating

Investigation: Building a Transformer

Purpose

In this investigation you will use the changing magnetic field of one coil to induce a current in another coil.

transformer – a device for increasing or decreasing AC voltage

Materials

You will need the following materials for this investigation:

• two pieces of 28 gauge enamelled copper wire: one 7.2 m long, one 3.6 m long
• a steel loose-leaf ring: 1 inch size
• a DC power supply capable of 12 V output
• a 30 Ω power resistor—5 W power handling
• a sensitive galvanometer or multimeter with a microampere scale for DC current measurements
• two pieces of masking tape each 10 cm long

Important Safety Precautions

It is very important that you read and apply the information in these safety warnings before you begin this investigation. Injury or death can occur even with low voltages and low currents.

- Never ground yourself while working with a live circuit. Do not touch objects, such as metal pipes, electric outlets, and light fixtures, that might be grounded. Be sure to keep your body insulated by keeping your hands and body dry and by wearing dry clothing and running shoes.

- Only replace the fuse inside the meter with the specified or approved equivalent fuse.

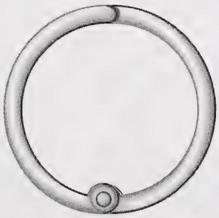
- Use the meter only as specified in the investigation. Do not use the meter to test a wall outlet or an electric appliance. If you try to measure a voltage that exceeds the limits of the meter, you may damage the meter and expose yourself to a serious electric shock.

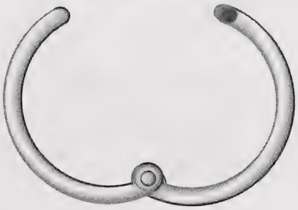
- Resistors can become warm and in some cases hot enough to cause burns. Always disconnect a recently used resistor and allow it to cool for a few minutes before handling.

You will ensure your own safety by applying this information as you complete the investigation.

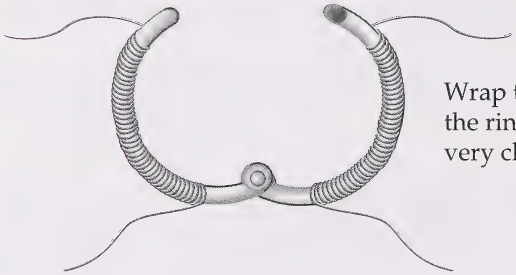
Procedure and Observations

- The first step is to build the transformer. This begins by opening the loose-leaf ring so that you can wrap the 7.2 m length of wire around one side and the 3.6 m length of wire around the other side. The following diagrams summarize how to do this.

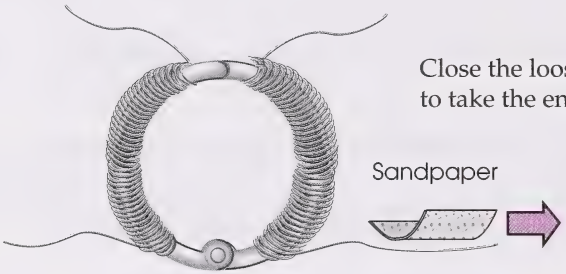




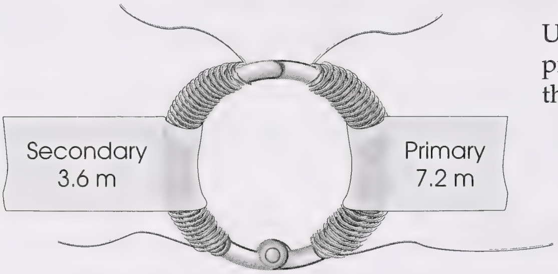
Open the loose-leaf ring as wide as it will allow.



Wrap the wire tightly around each side of the ring. Make sure that each turn of wire is very close to the one beside it.

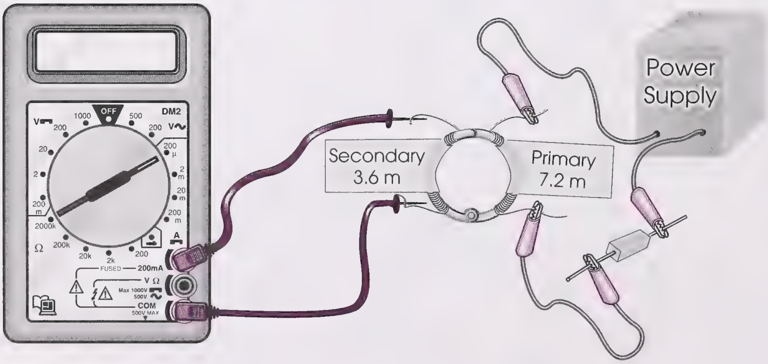


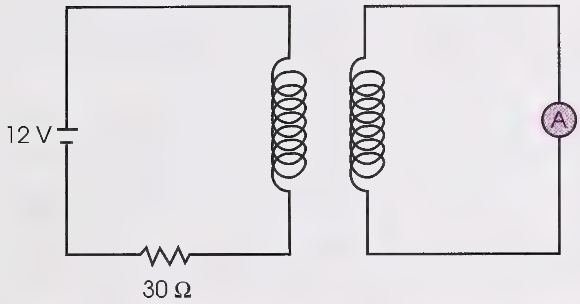
Close the loose-leaf ring and use sand paper to take the enamel off the ends of the wires.



Use tape to label the larger coil as the primary coil and the smaller one as the secondary coil.

- Without turning on the power supply, construct the circuit shown in the following illustration and schematic diagram.





Note that since the copper wire is insulated from the loose-leaf ring by the enamel, these are two separate circuits.

- Turn on the power supply and set the multimeter to measure microamperes.

- Watch the current reading through the secondary coil as you quickly disconnect the power supply from the primary coil.

5. Describe how the current reading through the secondary coil changed the instant that the power supply was disconnected from the primary coil.

- Carefully watch the current reading through the secondary coil as you reconnect the power supply to the primary coil.

6. Describe how the current reading through the secondary coil changed the instant that the power supply was reconnected to the primary coil.

7. Describe the current reading through the secondary coil as a steady current passes through the primary coil.

Analysis and Interpretation

8. In the previous investigation you moved a magnet to create a changing magnetic field. Concisely explain how you created the changing magnetic field in this investigation.

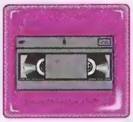
9. Describe the role played by the steel loose-leaf ring.

Conclusions

10. Describe the circumstances in which a current is observed in the secondary coil. Answer in terms of the current in the primary coil and in terms of the magnetic field flowing within the loose-leaf ring.

Check your answers by turning to the Appendix, Section 1: Activity 3.

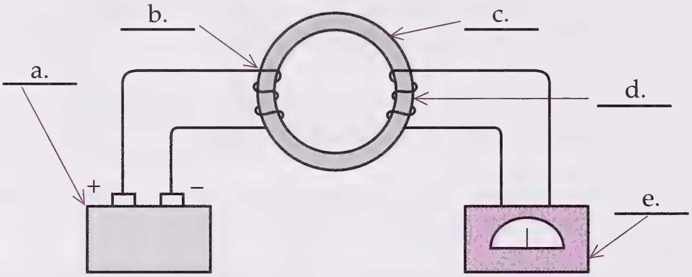
electromagnetic induction – a current induced in a coil when the strength of the magnetic field in the coil changes



The two previous investigations have introduced you to the idea of **electromagnetic induction**. You can get a better sense of what this is all about by watching some computer animation on a video program.

The video series *Electromagnetism* contains a ten-minute program called "Electromagnetic Induction." You may be able to obtain this video through your school or local library or you can purchase it through the Learning Resources Distributing Centre. Familiarize yourself with the following questions prior to watching the program. This will help you to focus on the main ideas while you are viewing. You may have to periodically stop the tape in order to record your answers.

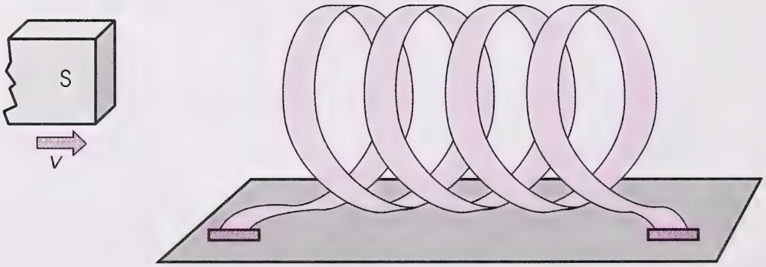
11. Michael Faraday is credited with the discovery of electromagnetic induction. Complete the question by providing the correct name for each part.



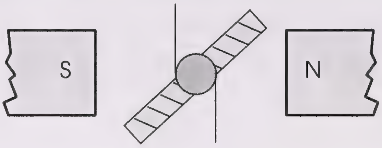
12. What is the name given to the device shown in the preceding diagram?

13. State Lenz's law as given in the video.

14. The following diagram represents Lenz's law in the diagram form shown in the video. Copy the diagram into your notebook and complete the diagram by indicating the magnetic polarity of the coil, the induced electron flow, and the magnetic field lines that surround the coil. Remember to use your left hand!



15. Refer to this diagram as you answer the questions that follow.



a. What did this diagram represent in the video?

b. What is the name for the rotating part between the poles of the magnet?

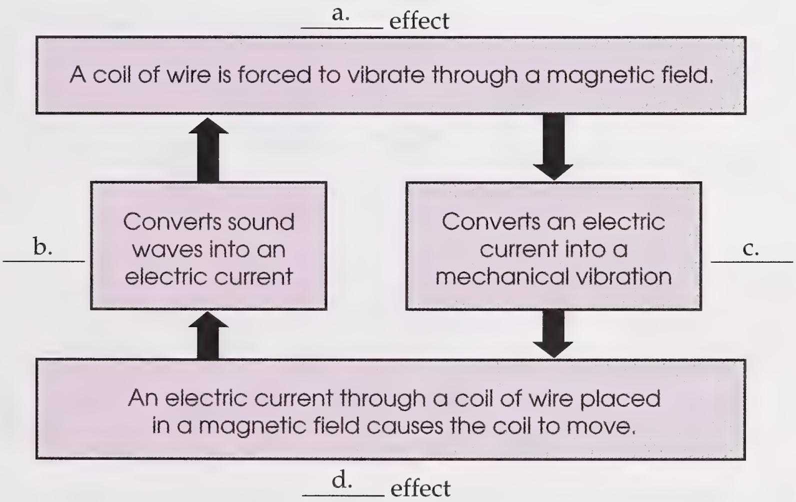
c. What happens as you turn the rotating part? Explain your answer.

Stop the videocassette at the end of the program.

Check your answers by turning to the Appendix, Section 1: Activity 3.

Something that you should notice as you study this topic is the strong connection to what you have already studied. For example, you should now be able to appreciate why a microphone and an earphone are similar in design. They both act as devices that translate one form of energy into another form of energy.

16. Examine the following diagram. Complete the question by matching the words *microphone*, *earphone*, *generator*, and *motor* to the correct letter.



17. Imagine that you are setting your tape recorder up to record an interview with a famous person. You notice that you have accidentally packed your earphones instead of your microphone. Fortunately, you are still able to record the interview. Explain how this is possible using only the equipment mentioned.

Check your answers by turning to the Appendix, Section 1: Activity 3.

Transformers play a very significant role in how electricity is made available to you as a consumer.

One of the best applications of transformers concerns how your home is supplied with AC power. Even though the transmission lines that leave the generating station can have AC voltages between 100 000 V and 500 000 V, the power that enters your house is only 110 V or 220 V. It is interesting to know how and why this occurs. You can find out more by reading pages 282 and 283 of your textbook and by answering the following questions.

Visions

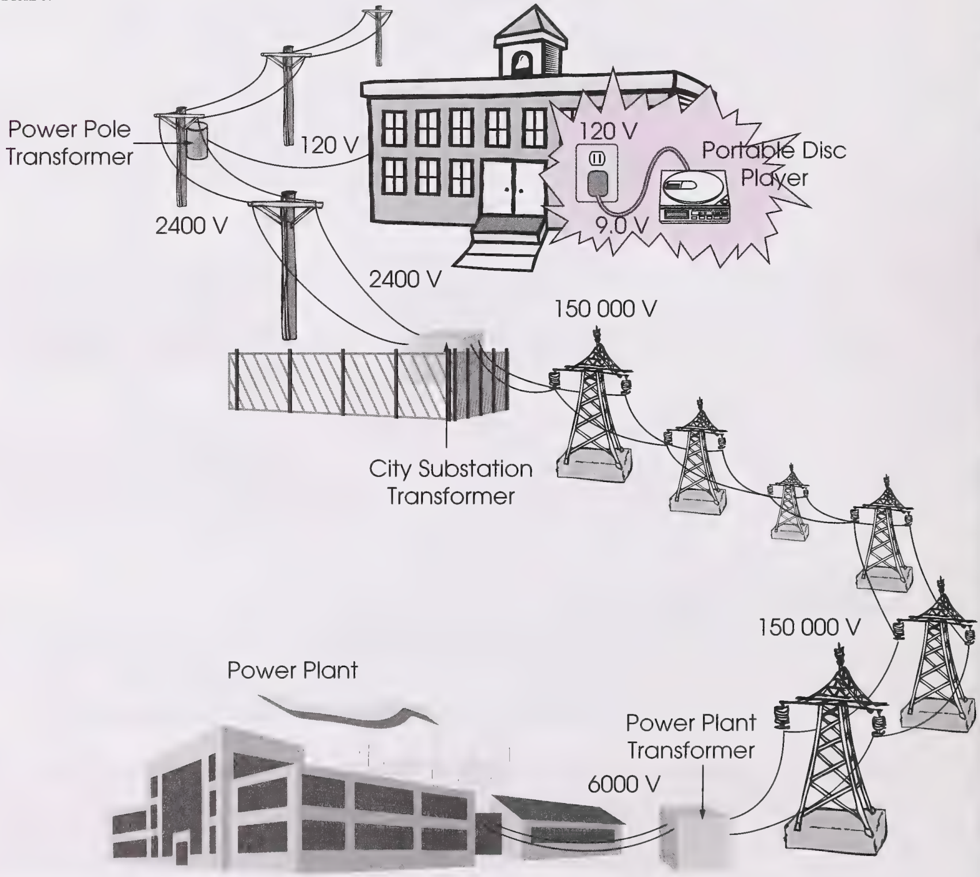
18. Do Checkpoint questions 3 and 5 on page 284 of your textbook.

Check your answers by turning to the Appendix, Section 1: Activity 3.

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☑ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

You can get a better sense of how transformers are used to step up or increase voltage and how they step down or decrease voltage by analysing the following illustration and chart.



Transformer	Primary Coil	Secondary Coil
Power Plant Transformer	Voltage = 6000 V # of turns = 2000	Voltage = 150 000 V # of turns = 50 000
City Substation Transformer	Voltage = 150 000 V # of turns = 62 500	Voltage = 2400 V # of turns = 1000
Power Pole Transformer	Voltage = 2400 V # of turns = 1000	Voltage = 120 V # of turns = 50
AC Adapter	Voltage = 120 V # of turns = 400	Voltage = 9.0 V # of turns = 30

19. The power plant transformer is the only step-up transformer in the illustration shown. The other three transformers are step-down transformers. Use this information to develop a definition for a step-up transformer.

20. Is there a trend in the data that describes a relationship between the primary coil and the secondary coil of each of these transformers? Analyse the data to find such a trend. Support your answer with calculations.

Transformers are really very efficient. They lose only 1 to 3% of their original input energy as thermal energy. Part of the reason for this is that a transformer has no large-scale moving parts, so losses due to friction or sound are minimal.

Science Skills
- ☑ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☐ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

21. Design a method to determine the efficiency of each of the transformers listed on the chart. Assume that the data on the chart is valid and that you can call electrical engineers to get other measurements that you may need.

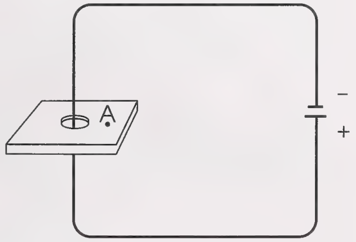
Check your answers by turning to the Appendix, Section 1: Activity 3.

Follow-up Activities

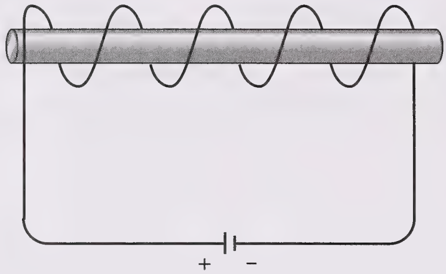
If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

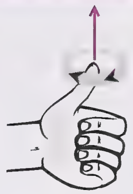
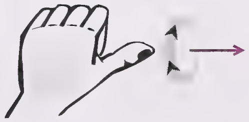
1. Use the appropriate hand rule to determine the direction of the magnetic field at Point A in the diagram.



2. Copy the diagram into your notebook. Use the appropriate hand rules to label the north and south poles of the electromagnet.



3. This module has introduced you to three different hand rules. Copy the following diagrams into your notebook. Note that you may decide only to draw the vectors if sketching the hands is too difficult. Be sure to leave enough space to record your answers. Complete the diagrams in your notebook by labelling each of the vectors indicated.

Rule	Variables
Left-hand Rule for Conductors	
Left-hand Rule for Coils	
Left-hand Rule for Force	

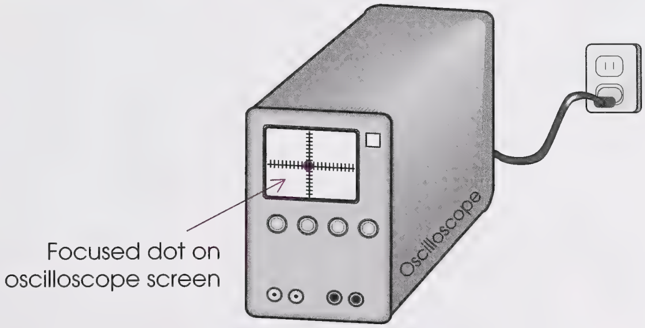
Check your answers by turning to the Appendix, Section 1: Extra Help.

Enrichment

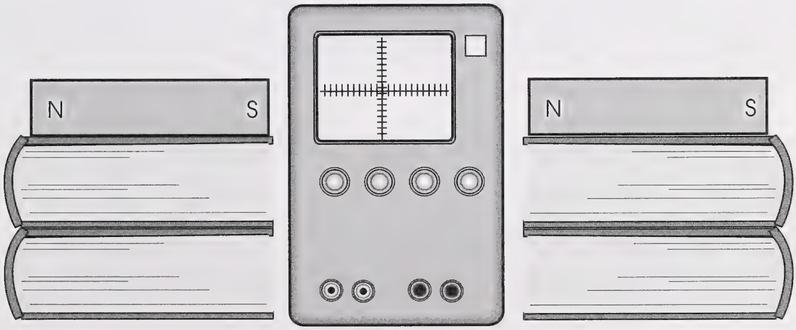
Do **one** of the following activities.

1. Observing Charged Particles in a Magnetic Field

   For this activity you will need an oscilloscope and two bar magnets. Adjust the oscilloscope so that the electron beam forms a focused dot in the centre of the screen as shown in the following diagram.



   Turn off the oscilloscope and place the bar magnets along the centre horizontal grid line as shown in the following diagram.



   a. Make a prediction about the direction in which the electron beam will be deflected when the oscilloscope is turned back on.

   b. Turn on the oscilloscope and verify your prediction. Did it work as you expected?

   c. Try moving the bar magnets into a variety of different positions. In each case, predict what will happen to the electron beam and then turn on the oscilloscope to verify your prediction.

2. Transformers

To increase or maintain the efficiency of a transformer, it is necessary to reduce the heat lost to the external environment. This involves insulating the transformer. A second condition is that hot spots must be avoided. The heat generated by a transformer may be considerable. Hot spots increase the resistance of any conductor and increase the likelihood of a burnout. Most transformers use a liquid as an insulator. Older transformers used a class of substances called polychlorinated biphenyls or PCBs. PCBs have been in the news a great deal in recent years. They have the useful properties of being extremely stable, having a high boiling point, and being unreactive. In addition, PCBs are non-flammable, making them easy to store and transport.

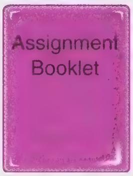
a. Why are PCBs so controversial if they have so many useful properties?

b. A large transformer filled with transformer oil is never a good thing to tamper with or take apart unless you are a trained professional. Explain why.

Check your answers by turning to the Appendix, Section 1: Enrichment.

Conclusion

In this section you discovered the operating principles behind mechanical motors, generators, and transformers. Using these principles you have solved problems relating to the generation and transfer of electric energy between a magnetic field and a nearby electric conductor. In the next section you will continue with the nature of electromagnetic transfer of energy through space in the absence of an electric conductor.



ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 1.

Section

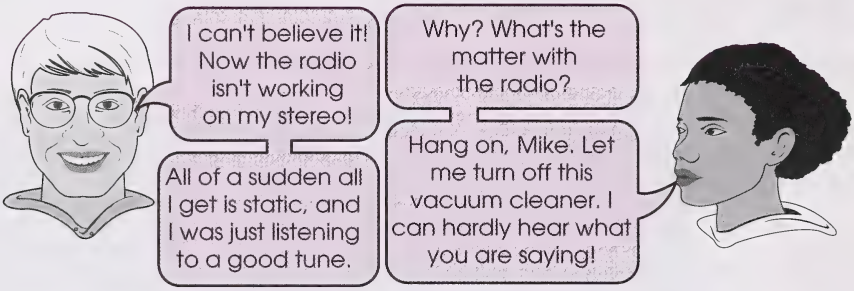
2 Electromagnetic Waves

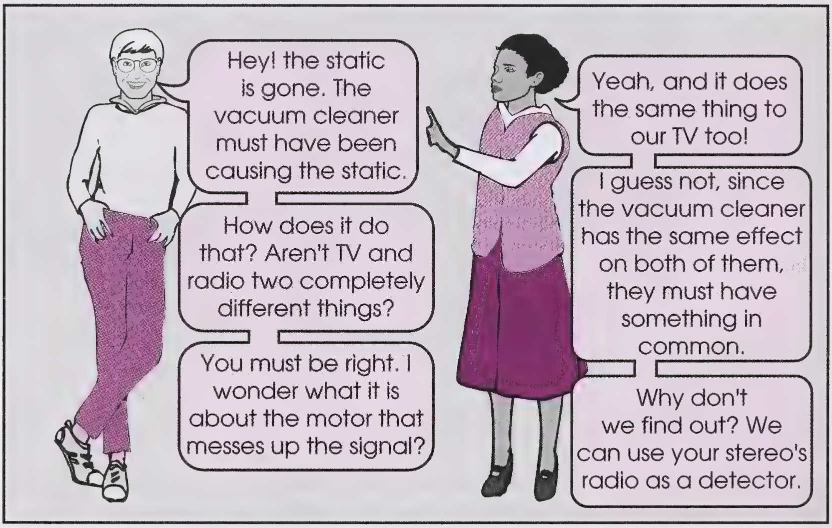
WESTFILE INC.

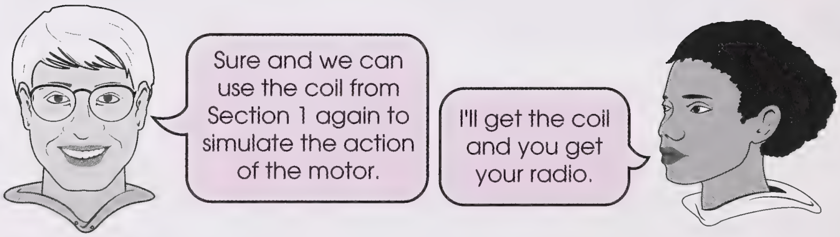
What does a speed limit mean to you? A speed limit is the maximum speed at which you are allowed to operate your vehicle under ideal conditions—dry pavement and maximum visibility. However, many motorists don't seem to follow these limits, as indicated by the number of speeding tickets and vehicle-related deaths every year. Police officers can be very accurate at determining the speed of a vehicle using a new laser light system that may eventually replace the traditional radar gun system. Why is the new laser light system more accurate? Is laser light similar to radar? What is radar?

In Section 1 you were introduced to the principles behind electromagnetic induction. In this section you will continue with the concept of electromagnetic induction, but will extend the concept to include the transfer of energy through space in the form of an electromagnetic wave. At the end of this section you should be able to summarize the events that occur in the creation or reception of electromagnetic radiation (EMR), predict and explain the propagation of EMR in relation to electromagnetic induction, solve mathematical problems relating to the wave properties of EMR, and perform simple experiments and simulations relating to the wave properties of EMR. In addition, you should be able to use your knowledge of wave properties to compare and contrast specific regions of the electromagnetic spectrum, including radar and visible light.

Activity 1: Experiencing Electromagnetic Waves







1. Mike and Nicole assume that it is the motor of the vacuum cleaner that is responsible for the interference with the radio. Why would they assume that?

2. Mike referred to using a coil to simulate the action of a motor. In what way does a coil resemble an electric motor?

Check your answers by turning to the Appendix, Section 2: Activity 1.

In the next investigation you will have an opportunity to observe the phenomenon that Mike and Nicole were talking about.

Investigation: Induction at a Distance

Science Skills
- ☐ A. Initiating
- ☑ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☑ E. Synthesizing
- ☐ F. Evaluating

Purpose

In this investigation you will explore the possible link between electromagnetic induction and radio waves.

Materials

You will need the following materials for this investigation:

- the coil constructed in the first investigation of Activity 3 in Section 1
- a steel bolt
- a variable power supply capable of 12-V DC output
- a radio, preferably portable
- a 30-Ω power resistor rated at 5 W

Important Safety Precautions

Caution

It is very important that you read and then apply the information in these safety warnings before you begin this investigation. Injury or death can occur even with low voltages and low currents.

- Never ground yourself while working with a live circuit. Do not touch objects, such as metal pipes, electric outlets, and light fixtures, that might be grounded. Be sure to keep your body insulated by keeping your hands and body dry and by wearing dry clothing and running shoes.

- Only replace the fuse inside the meter with the specified or approved equivalent fuse.

- Use the meter only as specified in the investigation. Do not use the meter to test a wall outlet or an electric appliance. If you try to measure a voltage that exceeds the limits of the meter, you may damage the meter and expose yourself to a serious electric shock.

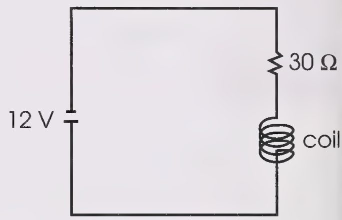
- Resistors can become warm and in some cases hot enough to cause burns. Always disconnect a recently used resistor and allow it to cool for a few minutes before handling.

You will ensure your own safety by applying this information as you complete the investigation.

Procedure

- Read through the entire procedure before starting the investigation.

- Without turning on the power supply, construct a circuit like the one on the right. Note that the power supply should be on the 12-V setting.



- Insert the steel bolt through the coil.

- Turn your radio so that it is **not** receiving any particular station. Place your radio about two meters away from the coil.

- Turn up the volume of the radio to the maximum setting. Since the radio is not on a station, you should hear only static noises.

- While carefully listening to the static noise from the radio, turn on the DC power supply. Connect and disconnect the lead between the DC power supply and the coil. Listen for any changes in the static noise as you do this.

3. Describe the change in the sound being output by the radio when the coil was disconnected and reconnected to the power source.

4. It is also a good idea to check the assumption that it is the coil causing the difference. What would happen if both leads were disconnected from the coil and touched together very briefly? Make sure that the power resistor is still in the circuit and try it.

Check your answers by turning to the Appendix, Section 2: Activity 1.

Analysis and Interpretation

5. In Section 1 you used two other coils and a steel loose-leaf ring to build a transformer. In order to observe an effect in that experiment, you had to disconnect and reconnect the transformer to the DC power supply. What enabled the primary coil to influence the secondary coil in that investigation?

6. Based on your answer to the previous question, speculate on what enabled the coil to influence the radio.

7. Your work with transformers has always involved an iron or steel core linking the primary and secondary circuits. Is there such a link in this investigation?

8. A radio is designed to receive radio waves. The radio's reception circuitry somehow responded to the changing magnetic fields of the coil. What does this suggest about the nature of radio waves?

Check your answers by turning to the Appendix, Section 2: Activity 1.

electromagnetic wave – a wave of changing electric and magnetic fields that travels through space

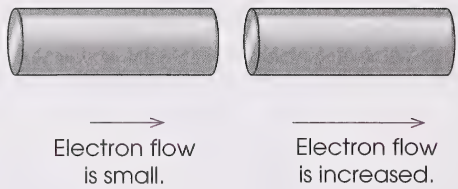
The previous investigation suggested that the magnetic fields produced by the coil travel through the 2 m of space between the coil and the radio and influence the radio's circuitry. You may be surprised to know that there was also an induced electric field present that travelled with the induced magnetic field in the form of an **electromagnetic wave**.

There are a number of types of electromagnetic waves. In the previous investigation you made a radio wave with your coil circuit. Other types of electromagnetic waves would include radar, microwaves, x-rays, and gamma rays. What you might find most surprising of all is the fact that light is also an electromagnetic wave.

You can get a good introduction to how electromagnetic waves were discovered and how these waves travel by watching some computer animation on a video program.

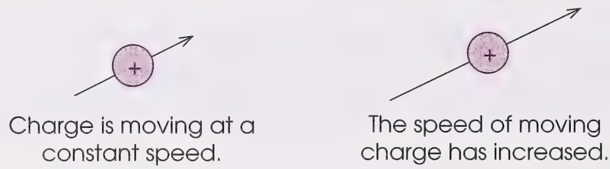
The video series *Wave-Particle Duality* contains a ten-minute program called "The Electromagnetic Model." You may be able to obtain this video through your school or local library or you can purchase it from the Learning Resources Distributing Centre. Familiarize yourself with the following questions prior to watching the program. This will help you to focus on the main ideas while you are viewing. You may have to periodically stop the tape in order to record your answers.

9. According to Oersted, wire that is carrying electron flow will generate a magnetic field that circles around the wire. Copy the following diagrams into your notebook. Complete the diagrams to show the change that occurs in the magnetic field around the wire when the electron flow increases. Make sure you indicate the direction of the field.

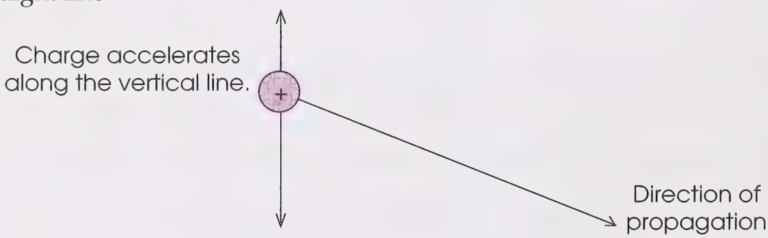


10. Describe a process by which the reverse could occur. How can a magnetic field be used to create an electric current?

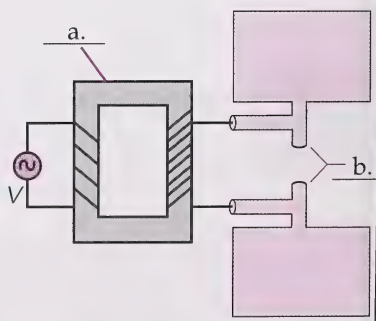
11. The wire is not absolutely necessary. Free electric charges moving through space also create magnetic fields. Copy the following diagrams into your notebook. Complete the diagrams by indicating the size and direction of the magnetic field which surrounds an electric charge moving at the indicated speed. Hint: The magnetic field is similar to that around a wire except that with a positive charge, the direction of the magnetic field is opposite to that of the wire.



12. Maxwell calculated that an accelerating, or oscillating, charge would create a special type of electric field. Copy the following diagram into your notebook. Complete the diagram by showing the electric field created by a particle oscillating along a straight line.



13. In 1887, Heinrich Hertz set out to find evidence for the existence of the waves predicted by Maxwell. Provide the correct name for each of the indicated parts in the diagram.



14. The device in the previous diagram is called a transmitter. Describe the function of each of the parts indicated in question 13.

15. What did Hertz use as a detector for the waves transmitted by this device? How did Hertz know that he had detected those waves?

16. The waves that Hertz detected would be called radio waves today. Maxwell's theory predicted that a range of wavelengths should be found. This range of wavelengths is referred to as the **electromagnetic spectrum**. List the types of electromagnetic waves from longest to shortest wavelength.

electromagnetic spectrum – the complete range of electromagnetic waves ordered according to frequency or wavelength

Stop the videotape at the end of the program.

Check your answers by turning to the Appendix, Section 2: Activity 1.

You can learn more about the work of Maxwell and Hertz by reading pages 296 to 298 of your textbook and by answering the following questions.

17. Why was it important for the receiving coil in Hertz's apparatus to be parallel to the oscillating spark?

18. Why was it so sensational when Hertz discovered that electromagnetic waves travelled at 3.00×10^8 m/s?

19. Write a concise definition for each of the following terms. You will find it helpful to think back to the video program and to draw a simple sketch to accompany each definition.

    a. Wavelength of an electromagnetic wave

    b. Frequency of an electromagnetic wave

20. The textbook presented an equation for calculating the speed of an electromagnetic wave. Identify the name, the units, and the symbol for each of the variables in this equation.

Check your answers by turning to the Appendix, Section 2: Activity 1.

How would you calculate the frequency or wavelength of an electromagnetic wave? The answer, according to Maxwell, was simple! Fortunately the complex equations used by Maxwell reduced down to a simple equation that you can find in your textbook—the universal wave equation $(v = f\lambda)$. Since electromagnetic waves always travel at the speed of light, c, in a vacuum or air, the equation becomes $c = f\lambda$.

As an example, police radar guns use electromagnetic waves that have a frequency of about 1.0×10^{10} Hz. The wavelength of these electromagnetic waves could be calculated as follows.

$$c = 3.00 \times 10^{8} \text{ m/s}$$
$$f = 1.0 \times 10^{10} \text{ Hz}$$
$$\lambda = ?$$

$$\begin{aligned} c &= f\lambda \\ \lambda &= \frac{c}{f} \\ &= \frac{3.00 \times 10^{8} \text{ m/s}}{1.0 \times 10^{10} \text{ Hz}} \\ &= 3.0 \times 10^{-2} \text{ m} \end{aligned}$$

Note that the unit Hz is equivalent to $\frac{1}{\text{s}}$. In this example the units Hz and $\frac{1}{\text{s}}$ cancel leaving only metres.

21. Red light has a frequency of 4.8×10^{14} Hz, while an AM radio station broadcasts on a frequency of 740 kHz.

    a. Calculate the wavelengths of these electromagnetic waves.

    b. Compare your answers to the wavelength of the waves emitted by the police radar gun.

    c. A motorist's radar detector uses an antenna and circuitry that is tuned to electromagnetic waves with a wavelength of about 3.0 cm. Why won't the radar detector be able to detect the red light from a police officer's laser light system?

22. Do Problems 1 to 3 on page 298 and 299 of your textbook. In each case use the format shown in the previous example.

Check your answers by turning to the Appendix, Section 2: Activity 1.

electromagnetic radiation – energy carried by electromagnetic waves through space

The implication of Maxwell's work was that the separate studies of electricity, magnetism, and light now came under the general name of **electromagnetic radiation**. As the definition implies, radio waves, microwaves, and visible light all transfer energy through space in the form of electromagnetic waves. Even though these waves all travel at the same speed through a vacuum, they have different wavelengths and frequencies.

In the next activity you will survey the properties of the many forms of electromagnetic radiation.

Activity 2: Exploring the Electromagnetic Spectrum

What makes a radio wave different from a microwave? How is infrared radiation different from gamma radiation? How are these electromagnetic waves used in different technologies? What parts of the electromagnetic spectrum have the greatest impact on your life?

In this activity you will answer these questions as you survey the electromagnetic spectrum. Each type of electromagnetic wave will be described by answering the following questions:

- What is the range of frequencies for this kind of wave?
- How is this type of wave produced?
- How can this type of wave be detected through its interaction with matter?

This format of presentation will be used with each type of wave so that you can identify trends and readily compare and contrast the different wave types.

Radio Waves

Radio waves occupy a region of the electromagnetic spectrum from about 100 kHz to about 500 MHz. This part of the spectrum includes AM and FM radio signals and TV broadcasting signals. Radio waves occur naturally due to lightning strikes on Earth and due to the behaviour of atoms and molecules in outer space. Artificial radio waves are created by causing electrons to oscillate in a broadcast antenna at a frequency called the **carrier frequency**. The electromagnetic waves created by this antenna have the same frequency as the oscillating electrons.

carrier frequency – the frequency used to carry a communication signal

To find out how an antenna creates electromagnetic waves, read from the top of page 299 to the middle of page 300 in your textbook.

1. Why is it important for the electrons in the antenna to be vibrating back and forth?

2. Use a simple diagram to help explain the differences between AM and FM radio waves.

Check your answers by turning to the Appendix, Section 2: Activity 2.

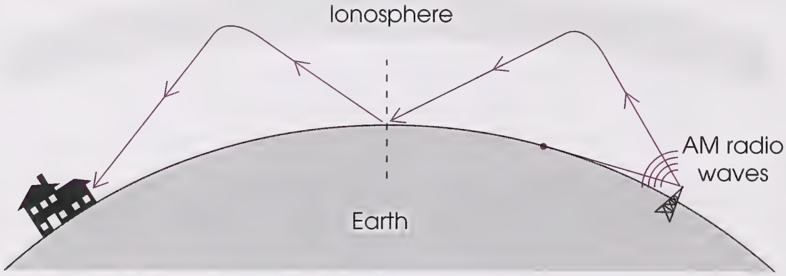
Radio waves are used extensively for communication because they are the easiest to produce and detect. It's important to realize that the carrier wave can be used to carry information in a number of different ways.

AM Radio

When the radio waves have the signal coded in the amplitude of the wave they are said to be **amplitude modulated**, or AM, waves. These waves exist in a band from about 500 kHz to about 1600 kHz.

ionosphere – an upper layer of the atmosphere containing charged particles

AM radio waves have the interesting property of being able to reflect off a layer of charged particles in the upper atmosphere, called the **ionosphere**. This means that if there is sufficient energy in the signal, these waves can be bounced off the ionosphere and then detected hundreds or even thousands of kilometres away.

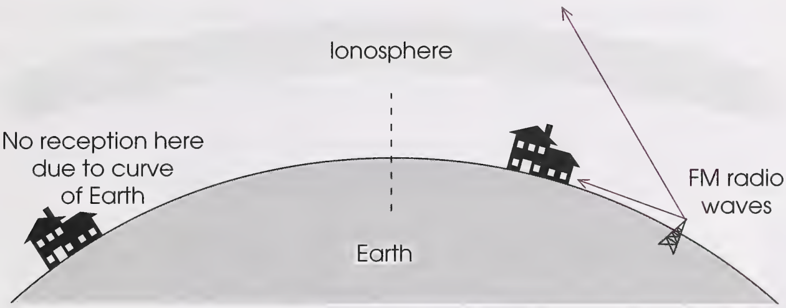


The signal can also bounce off Earth and greatly increase the range of transmission. Otherwise the curve of Earth would greatly reduce the range of the signal.

FM Radio and TV

Radio waves that have the signal coded in the frequency of the wave are said to be **frequency modulated**, or FM. This description also includes TV signals. TV channels 2 through 6 can be found in a band from 54 MHz to 88 MHz, while channels 7 through 13 are broadcast in a band between 174 MHz and 216 MHz. FM radio is broadcast between these two sets of TV channels at 88 MHz to 108 MHz.

These frequency modulated bands do not bounce off the ionosphere, so their reception area is limited by the curve of Earth. This means that the broadcast range is usually less than 100 km.



One advantage of this property is that these signals can be used to communicate beyond the planet (the moon) since the signals can penetrate the atmosphere.

3. Calculate the range of wavelengths for the FM radio band.

Check your answers by turning to the Appendix, Section 2: Activity 2.

The reception of all types of radio waves is the inverse process of how they are created. Instead of a broadcast antenna generating the waves, the waves induce oscillating charges in the antenna of the receiver.

Microwaves


PHOTO SEARCH LTD.

This band of the electromagnetic spectrum occupies a region from about 10^8 Hz to 10^{12} Hz. Even though you may first think of microwaves ovens, this band also includes radar and telecommunication signals.

This band is far removed from the AM range, and therefore the effect of reflection from the ionosphere has little influence on these signals. This is why this band is preferred for satellite telecommunication systems.

Unlike the radio waves that you examined earlier, microwaves require higher frequencies that are difficult to produce with an electronic circuit and antenna. These waves are usually created by charges vibrating in a resonant cavity that determines the frequency of the wave. If you have a microwave oven, it will contain such a cavity.

When microwaves strike matter, they can accelerate electrons within molecules, causing thermal energy to be produced. Most microwave ovens operate at a frequency of 2.45×10^{9} Hz, since this frequency is particularly effective at exciting water molecules.

4. Calculate the wavelength of the electromagnetic waves generated by most microwave ovens. Assume that the microwaves are travelling through air.

Visions

You can learn more about the applications of microwaves by reading the second, third, and fourth paragraphs on page 315 of your textbook. Include the Did You Know parts in the margin on page 315 in your reading.

5. How was the potential for microwaves as a cooking device first discovered?

6. Why is it important for the doors of microwave ovens to include a metal screen with tiny holes?

Check your answers by turning to the Appendix, Section 2: Activity 2.

Infrared Radiation

Electromagnetic waves with a frequency of about 10^{12} Hz to 10^{14} Hz are usually classified as infrared radiation. These waves have a frequency that matches the natural rate of vibration of most molecules. This describes how these waves are created and detected. Warm objects will emit infrared radiation because their molecules are vibrating within this frequency range. Similarly, if you hold your hand close to a hot object, you will feel the result of the infrared radiation being emitted as a warm sensation in your hand.

As the name implies, these rays are almost red. The infrared waves with the shortest wavelengths have properties very similar to the visible spectrum. For example, infrared detectors can be used to identify areas of heat loss in buildings or regions of abnormal blood flow in the body by using a special type of film that is sensitive to this type of radiation.

7. Explain why infrared detectors are so useful in search-and-rescue operations, particularly when looking for people at sea or in dense bush.

8. What is the range of wavelengths for infrared radiation travelling in a vacuum?

Visions

An interesting application of infrared radiation concerns how mosquitoes locate their next blood meal. You can learn more about this by reading the last paragraph on page 315 which runs onto page 316 in *Visions 3*.

9. Explain why standing next to a warm thermal source is a good way to avoid mosquito bites.

Check your answers by turning to the Appendix, Section 2: Activity 2.

Visible Light

The human eye is sensitive to electromagnetic waves with a frequency of 4.0×10^{14} Hz to 7.5×10^{14} Hz. When compared to the other types of electromagnetic radiation, this is a very narrow band within the whole electromagnetic spectrum.

Visible light is created by the movement of electrons within the energy levels of atoms. In a similar way, visible light can be detected when the electrons within atoms absorb energy.

When visible light strikes atoms, the outcome is often a chemical change. The development of photographic film and the process of photosynthesis are examples of chemical changes caused by light.

10. Theatre companies often use special spotlights equipped with colour filters to project different colours onto the stage. This can create a special mood for a particular scene or accentuate the colours of the costumes.

    a. If a red filter on a spotlight mainly transmits light with a wavelength of 6.6×10^{-7} m, then what is the frequency of this light?

    b. Calculate the frequency of the transmitted light for a blue filter that mainly transmits light with a wavelength of 4.8×10^{-7} m.

You'll learn more about the properties of visible light in the next activity.

Check your answers by turning to the Appendix, Section 2: Activity 2.

Ultraviolet Light

This type of electromagnetic wave occupies a frequency band from about 8×10^{14} Hz to 3×10^{17} Hz. As the name implies, this frequency range exists in a region beyond violet. Ultraviolet light is similar to visible light in that it is caused by electron energy transitions within atoms and it can cause chemical reactions in which radiant energy is used to break chemical bonds. The big difference is that this form of radiation delivers much more energy to a chemical reaction than visible light does.

One example of this type of reaction is the creation of ozone in the upper atmosphere. When ultraviolet light collides with oxygen molecules (O_2) in the upper atmosphere, the oxygen atoms are separated from each other and they combine with another oxygen molecule to form ozone (O_3).

Although the ozone layer is a very low-density veil of gas, it has an important function because it can absorb wavelengths of ultraviolet light that are not absorbed by any other atmospheric components.

Another example of a chemical reaction caused by ultraviolet light is the breaking of chemical bonds within skin cells that are exposed to ultraviolet light. Long-term exposure to ultraviolet light can lead to an increased risk of skin cancer, blotchy skin discolouration, and premature aging. You'll learn more about this in the next section.

11. Explain why decreases in the ozone layer led Canadian scientists to develop a system for measuring the intensity of UV radiation at ground level. The UV index that accompanies most weather forecasts is the outcome of this system.

Check your answers by turning to the Appendix, Section 2: Activity 2.

X-rays

X-ray radiation is usually classified in a band from about 3×10^{17} Hz to about 5×10^{19} Hz, although it is possible to have x-rays with frequencies as high as 10^{25} Hz. X-rays have even more energy than ultraviolet light and therefore are potentially more dangerous.

Visions

To find out how x-rays are created, read the second and third paragraphs on page 316 of your textbook.

12. How are x-rays produced?

13. A picture on a TV screen is created when electrons shot from the back of the set strike a special coating on the inside of the screen. Why do you think the face plate glass of a TV set contains lead?

Check your answers by turning to the Appendix, Section 2: Activity 2.


NASA

The penetrating power of x-rays has made them an excellent diagnostic tool for medicine. The x-ray in the centre of the picture on the right is from a person with scoliosis, a disease characterized by progressive curvature of the spine. The x-ray on the left shows the improvement over time that is possible through the use of a high-technology back brace.

Another application of x-rays in medicine is the imaging of internal organs. In this case low-energy, or "soft," x-rays are used to produce images of the heart on a monitor. The cardiologist can use these images to help guide a special catheter that is used to clear a blocked artery.

It is interesting to note that the new technology here is not the x-rays, but rather the computer imaging system which is used to add detail to the images. An enhanced image helps the cardiologist to be more accurate and increases the chances for a successful procedure.

14. Cardiologists who have access to cardiac imaging technology claim that one of the system's greatest strengths is that they can use a non-surgical technique to get in and out of the heart as quickly as possible. Why are these characteristics so important?

Check your answers by turning to the Appendix, Section 2: Activity 2.

Although x-rays are very useful, they should not be used indiscriminately. X-rays are classified as a type of ionizing radiation, because when an x-ray strikes an atom, it can ionize the atom. This occurs by the x-ray losing its energy to one of the atom's electrons, which in turn causes the ionization. In living tissues this ionization may directly affect a cell part, such as a mitochondrion, or it may effect other molecules needed by the cell, such as water. This may lead to the malfunction or death of the cells and eventually to the death of the whole organism.

The most serious effects occur when x-rays cause changes in a cell's DNA, which is the most important material in the cell. This helps explain why cells are most sensitive to x-ray radiation when they are actively growing. This is when they replicate DNA and undergo cell division. The most sensitive cells in the body are those that do the most active dividing. In adults this means that cells found in bone marrow, skin, and the lining of the intestine are the most sensitive to ionizing radiation. Excessive radiation exposure in these areas often leads to cancers.

15. Why are fetuses and infants much more readily harmed by ionizing radiation than adults?

16. Why are x-rays not recommended for pregnant women?

17. Although ionizing radiation is hazardous, why is it misleading to say that all types of radiation are bad? Support your answer with examples.

Check your answers by turning to the Appendix, Section 2: Activity 2.

The particular imaging system which helps the cardiologist see soft tissue is a spin-off of image processing technology that was originally developed for NASA satellites that were surveying Earth's surface from space. This topic is known as remote sensing technology.

Remote Sensing Technology

Canada is a world leader when it comes to getting images from satellites in space. The images are obtained by detecting different types of electromagnetic radiation that reflect from Earth's surface. You can learn more about this by visiting your local library and using the resources there to answer the following questions.

18. List the applications of remote sensing technology.

19. Name the types of electromagnetic radiation that are used to obtain images of Earth from space. In each case include a concise description as well as the frequency or wavelength range.

Check your answers by turning to the Appendix, Section 2: Activity 2.

Gamma Rays

Gamma radiation is considered to be the most hazardous form of electromagnetic radiation. Gamma rays are mainly emitted by the unstable nuclei of natural or artificial radioactive materials. You'll learn more about this process in future modules. Although the gamma ray portion of the electromagnetic spectrum overlaps the x-ray portion, it is the way that each type of ray is created that separates the two. Most gamma ray radiation has a frequency higher than 5×10^{19} Hz. Gamma rays are similar to x-rays in that they are considered a type of ionizing radiation, but the penetrating ability of gamma rays and their higher energy content makes them a more serious threat to living tissues. The effects of gamma radiation are much more severe than those of x-rays.

Visions

Read from the last paragraph on page 316 to the bottom of page 317 in your textbook to find out more about gamma rays.

20. Explain how gamma radiation is used to prevent the spoilage of potatoes.

21. Concisely explain how gamma rays are used as a diagnostic tool in medicine.

22. Cancer cells are often characterized as cells that are rapidly growing out of control. Why would these cells be particularly vulnerable to gamma rays from a source like radioactive cobalt 60 as a treatment for cancer?

Check your answers by turning to the Appendix, Section 2: Activity 2.

This activity was meant to be an overview of the many types of electromagnetic radiation.

In the next activity you will discover some of the specific properties of electromagnetic radiation by completing investigations with visible light.

Activity 3: The Properties of Light

The last activity gave you a sense of the range that exists within the electromagnetic spectrum. Radio waves have wavelengths nearly a kilometre long while gamma radiation can have wavelengths smaller than even the smallest subatomic particles. Each type of radiation has its own unique effects on matter and each type has its particular way of being produced. However it would be wrong to say that all these types of radiation have little in common.

You've already learned that each type of electromagnetic wave travels at the same speed in a vacuum—the speed of light. Just as visible light was the first type of radiation to be studied in depth because humans can detect it so easily, visible light will be used in this activity to explore properties common to all forms of electromagnetic radiation. Light will be the type of radiation investigated but the properties will apply to all forms of electromagnetic radiation.

Reflection

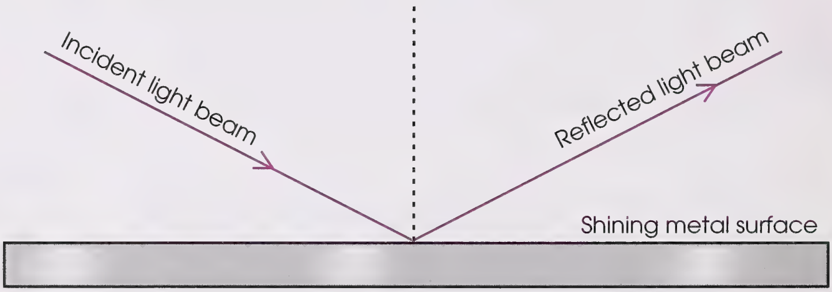
People who enjoy canoeing usually find the early morning or late evening to be the best time for enjoying perfectly still water. At these times the water is almost perfectly flat and acts very much like a mirror.

The water on this lake is so still that it is just like a mirror and is able to reflect the surrounding scenery perfectly.

The next investigation will allow you to study the behaviour of light during reflection.

Before starting the investigation read the first paragraph on page 304 of your textbook and answer the following question.

1. Copy the following diagram into your notebook. Complete the diagram by labelling the normal, the angle of incidence, and the angle of reflection.



Check your answers by turning to the Appendix, Section 2: Activity 3.

Investigation: The Reflection of Light

Science Skills
- [ ] A. Initiating
- [x] B. Collecting
- [x] C. Organizing
- [x] D. Analysing
- [ ] E. Synthesizing
- [ ] F. Evaluating

Do Activity 9.2 Investigating the Reflection of Light on pages 304 and 305 of *Visions 3*.

Purpose

2. Read the Planning section of Activity 9.2 and state the purpose of this investigation.

Materials

The materials are given on page 304 of *Visions 3*.

Procedure

Follow the instructions presented on pages 304 and 305 in your textbook. The only modification required is that you should use a scrap piece of corrugated cardboard or other soft material under your piece of paper so that the pins will be easier to insert. An additional hint is to use a full piece of paper for the pin sighting so you can be more precise.

Observations

3. Record your data in a data chart.

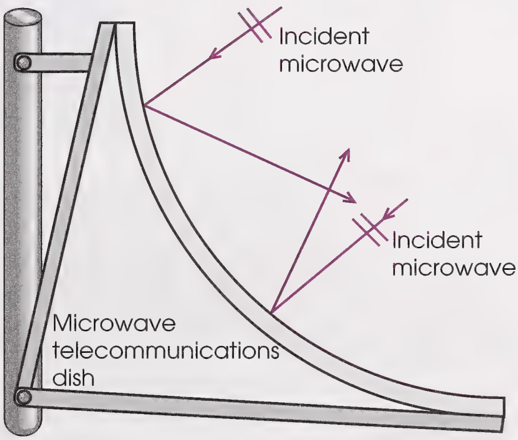
Analysis and Interpretation

4. Do Analysis and Interpretation questions 1, 2, and 3 on page 305 of your textbook.

5. In the previous activity a diagram was presented that showed AM radio waves reflecting of Earth. Return to this diagram and measure the angles of incidence and reflection for this case.

You can find out about some of the more interesting applications of reflection by reading the last paragraph on page 305 and by carefully examining the figure on the top of page 306 in your textbook.

6. Use a protractor to verify the law of reflection for the two sets of rays shown in the diagram. Note that you will need to construct a normal for each set of rays.

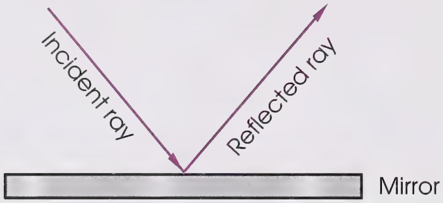


7. Refer to the diagram of the microwave dish in the previous question as you answer the following.

   a. What would be the best location for the detector of the microwave radiation?

   b. How would the diagram have to be changed if this microwave dish was transmitting instead of receiving the two rays shown?

8. The following diagram shows a beam of light reflecting off a mirror. Use a protractor to determine the value for the angle of reflection.



Check your answers by turning to the Appendix, Section 2: Activity 3.

Refraction

Have you ever looked across a large, flat area like a highway surface that was being heated by the sun on a clear day? In these circumstances it is not uncommon to see what appears to be a shimmering pool of water off in the distance. Invariably this is a mirage caused by the light from the sky bending as it encounters the heated air. **Refraction** is the term that is used to describe this bending.

refraction – the bending of a wave due to a sudden change in the medium in which it travels

You can study the refraction of light by carefully tracing its path as it travels from air into a block of glass.

Science Skills
- [ ] A. Initiating
- [x] B. Collecting
- [x] C. Organizing
- [x] D. Analysing
- [ ] E. Synthesizing
- [ ] F. Evaluating

Investigation: The Refraction of Light

Visions

Do Activity 9.3 Investigating Refraction on pages 307 and 308 of *Visions 3*.

Purpose

9. Read the Planning section on page 307 and state the purpose of this investigation.

Materials

The materials are listed on page 307 of your textbook. Omit the thin-walled clear plastic tank and water. Note: A lucite block may be used in place of the glass block.

Procedure

Visions

The activity on pages 307 and 308 of your textbook will form the basic outline for this investigation. You will simplify the process outlined in the text by making the following modifications:

- Only use the glass block. You will not use the small tank filled with water.
- Only record the angles of incidence and refraction as shown in Figure 9.8 on page 307 of your textbook. Omit step 7 of the procedure in the textbook.
- Use a piece of corrugated cardboard or other soft material under the piece of paper so that the pins will be easier to insert.

Observations

10. Record your measurements of the angles of incidence and refraction neatly in a chart.

Analysis and Interpretation

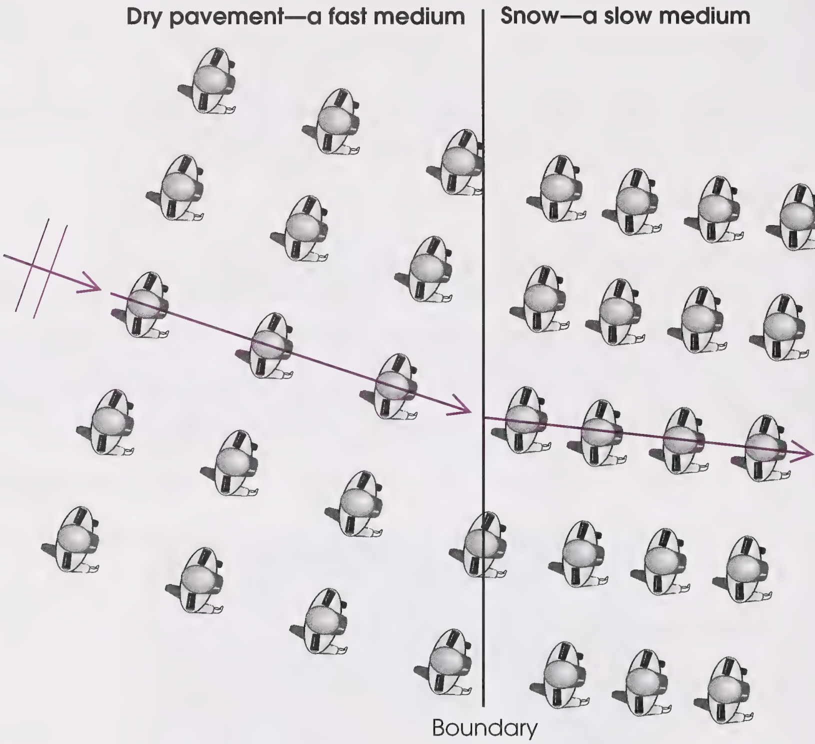
11. Identify the manipulated and responding variables.

12. Study your data. How do the angles of incidence in air compare to the angles of refraction in glass?

Check your answers by turning to the Appendix, Section 2: Activity 3.

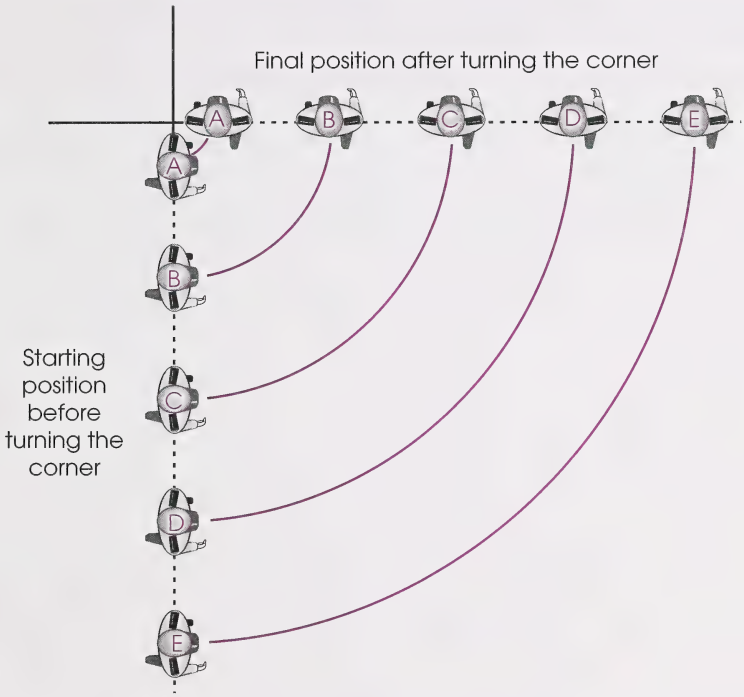
The basic idea that explains refraction has to do with the speed of the wave. As the wave encounters a new medium the speed changes and this causes the wave to change direction. You can understand this better if you think of a marching band.

A marching band that is practising on dry pavement may exhibit refraction when it suddenly encounters knee-deep snow. The following diagram helps to illustrate this idea.



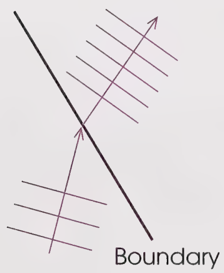
When the members of the marching band reach the snow, they are forced to travel slower. Since they are travelling at a reduced speed, the marchers in each column bunch together. This can be noted by comparing the spacing between the marchers in the snow to the spacing between the marchers on the dry pavement. Not only are the columns affected, but the rows change, too. Because the marchers travel slower when they reach the snow, they fall behind the other members in the same row who are still on the dry pavement. The result is that the whole row of marchers changes direction when it encounters the snow. The idea of one side of an object travelling slower while the other end travels faster to produce turning is also used by bulldozers and tanks.

13. Imagine that you are given the job of teaching a row of people in a marching band how to turn a corner while staying in a straight row. Write concise instructions for band members A to E so that they properly turn the corner.

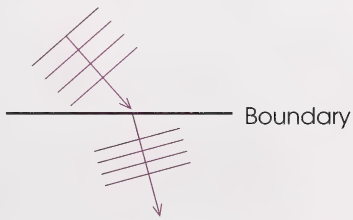


14. The following diagrams show light waves passing from air to glass or from glass to air. Label each side of the boundary as being either air or glass. Remember that air is a fast medium and glass is a slow medium. (Hint: Imagine that the incident wave is made up of rows of marchers instead of rows of crests. Would the first marchers who hit the boundary have to speed up or slow down to move in the new direction?)

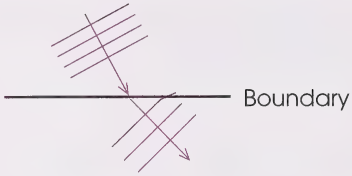
a.



b.

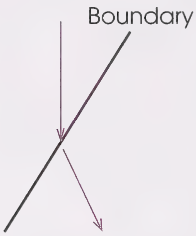


c.

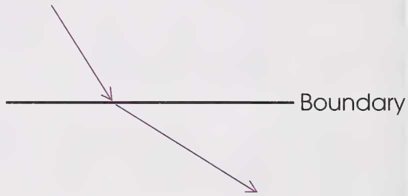


15. The following diagrams show the rays for light waves. Label the sides of each boundary either air or glass. Since the wave crests are not shown, you may find it helpful to lay your pencil perpendicular to the wave ray and slide it towards the boundary. Ask yourself whether the part of your pencil that first crosses the boundary must speed up or slow down to produce the refracted ray shown.

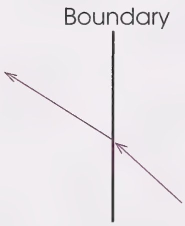
a.



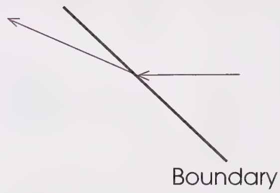
d.



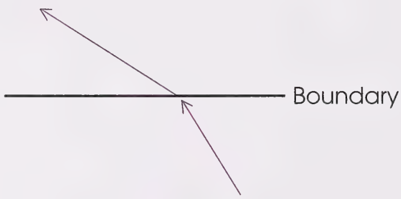
b.



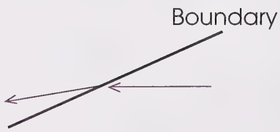
e.



c.



f.



16. Use a protractor to draw a normal on each of the previous diagrams. Label the angle between the wave ray and the normal on the air side as θ_{air}. Label the angle between the wave ray and the normal on the glass side as θ_{glass}.

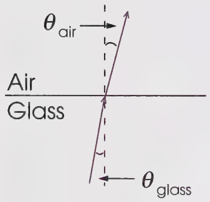
17. Compare the size of θ_{air} to θ_{glass} in each diagram that you labelled in question 15. State a rule about which medium will have larger angles to the normal.

Check your answers by turning to the Appendix, Section 2: Activity 3.

The answers to the previous questions indicate quite clearly that when light passes from a slower medium like glass to a faster medium like air, the angle gets larger as the light waves bend away from the normal. In other words, the angles in air will always be larger than the angles in glass. This creates an interesting situation for light passing from glass into air because there is a limit as to how large the angle in glass can be and still have refraction occur. The following diagrams show the steps in an experiment which was designed to find the largest angle in glass that still allowed refraction to occur.

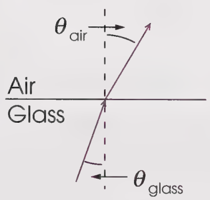
Step 1: $\theta_{glass} = 10.0°$

$\theta_{air} = 15.1°$



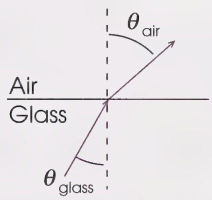
Step 2: $\theta_{glass} = 20.0°$

$\theta_{air} = 30.9°$



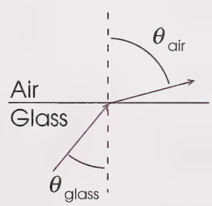
Step 3: $\theta_{glass} = 30.0°$

$\theta_{air} = 48.6°$



Step 4: $\theta_{glass} = 40.0°$

$\theta_{air} = 74.6°$

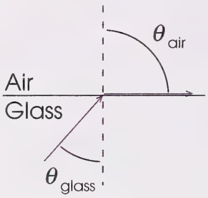


critical angle – incident angle in a slow medium for which the angle in the fast medium is 90°

Step 5: $\theta_{glass} = 41.8°$

$\theta_{air} = 90°$

This is the **critical angle** for glass.

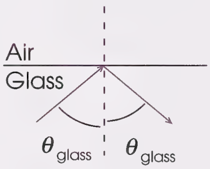


total internal reflection – occurs when light attempts to pass from a slower medium into a faster medium at an angle greater than the critical angle

Step 6: $\theta_{glass} = 50°$

θ_{air} does not exist

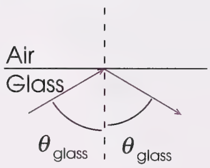
Total internal reflection occurs.



Step 7: $\theta_{glass} = 60°$

θ_{air} does not exist

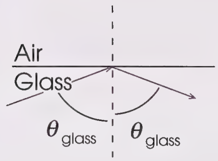
Total internal reflection occurs.



Step 8: $\theta_{glass} = 70°$

θ_{air} does not exist

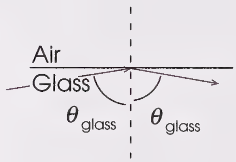
Total internal reflection occurs.



Step 9: $\theta_{glass} = 80°$

θ_{air} does not exist

Total internal reflection occurs.



18. What is the proper name for the largest angle that can occur in the slow medium that still allows refraction to occur?

19. What occurs for all angles in glass that are larger than the critical angle?

20. Why isn't there a critical angle for light when it passes from air into the glass?

You can learn more about the applications of total internal reflection by reading page 310 and the first paragraph on page 311 of your textbook.

21. Why is total internal reflection used in the design of periscopes and binoculars instead of mirrors?

22. What are the advantages and disadvantages of a fibre optics telecommunications system?

Check your answers by turning to the Appendix, Section 2: Activity 3.

Polarization

Have you ever gone downhill skiing on a sunny day? The reflected light or glare from the snow can be incredible. The glare from the surface of a lake in the summer can be just as severe. One way to protect your eyes in these circumstances is with a good pair of polarized sunglasses. The polarized coating on the glasses is specially designed to filter out the glare from horizontal surfaces.

Visions

How does the polarized coating do this? You can begin to answer this question by finding out what makes light polarized in the first place. Read the last paragraph on page 311 of your textbook and answer the following question.

23. What criteria decides if a wave is polarized?

Check your answers by turning to the Appendix, Section 2: Activity 3.

polarization – causing a wave to travel in one plane

The next investigation will allow you to investigate **polarization** further.

Investigation: Observing the Polarization of Light

Science Skills
- [ ] A. Initiating
- [x] B. Collecting
- [x] C. Organizing
- [x] D. Analysing
- [x] E. Synthesizing
- [ ] F. Evaluating

Purpose

In this investigation you will observe light as it passes through one or two polarizing filters.

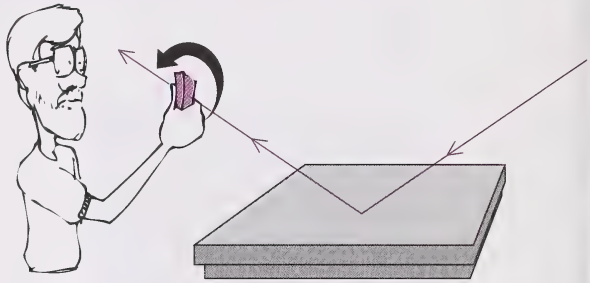
Materials

You will need the following materials for this investigation:

- two polarizing filters
- a light source
- a smooth horizontal surface

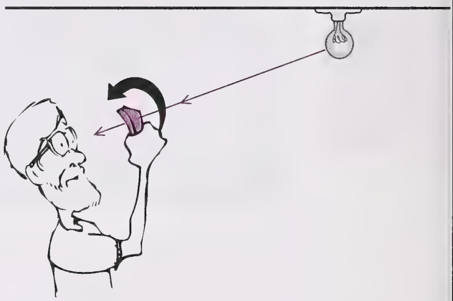
Procedure and Observations

- Observe the light that is reflected from a smooth horizontal surface through the polarizing filter. Rotate the filter as you look through it.



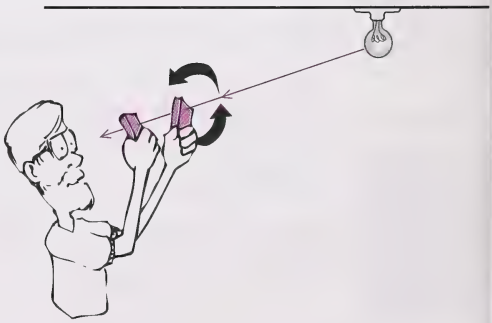
24. What do you observe as you rotate the filter?

- Observe the light from a light source through a polarizing filter. Rotate the filter as you look through it.



25. What do you observe as you rotate the polarizing filter?

- Observe the light from a light source through two polarizing filters. Hold one filter still and rotate the second filter.

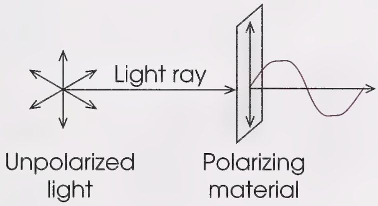


26. What do you observe as you rotate one of the filters?

What you observed can be explained by studying a property of light called polarization.

Analysis and Interpretation

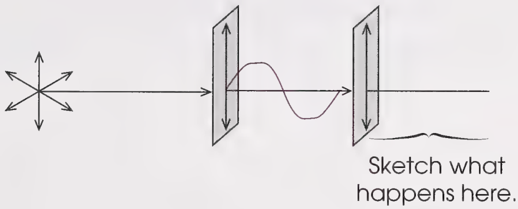
The following diagram summarizes what a polarizing filter does to an unpolarized light wave.

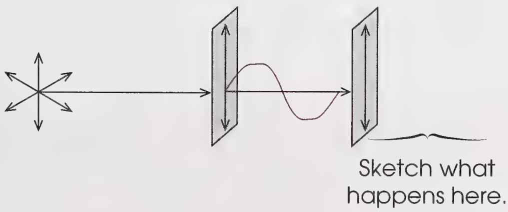


The unpolarized light contains many rays that vibrate in many different directions.

The polarizing material only allows light rays to pass that have their electric field vibrating **vertically**. This is due to the arrangement of the molecules on the special coating.

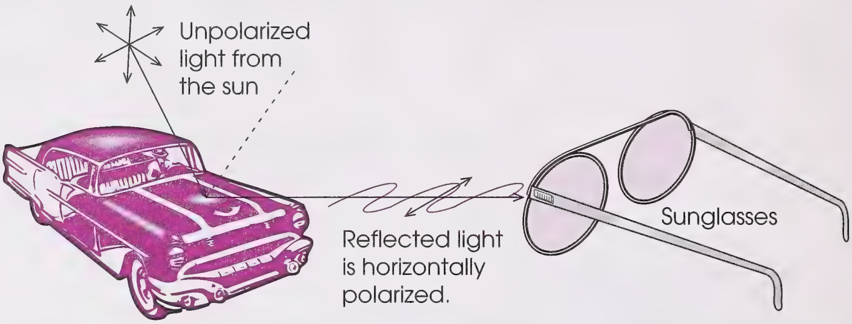
27. A second polarizer can be placed as shown. Explain what happens by completing the following sketches.





Conclusions

28. When light reflects from horizontal surfaces it is horizontally polarized as shown in the following diagram. Complete the diagram by showing the orientation of the polarized coating on the sunglasses that would filter out the light reflected from horizontal surfaces.



Check your answers by turning to the Appendix, Section 2: Activity 3.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

1. In this section you learned about three properties of light that can be applied to all electromagnetic waves. Summarize what you have learned about these properties by making a copy of the following chart in your notebook and by completing the chart by adding the appropriate information under each heading. Be sure to leave enough space under each heading to record your answers.

Property	Diagram to Summarize the Property	Applications
Reflection		
Refraction		
Polarization		

2. Copy the following headings into your notebook. Be sure to leave enough space under each heading to record your answers. Complete the chart by recording the appropriate information under each heading.

	Radio Waves	Micro-waves	Infrared Radiation	Visible Light	Ultraviolet Light	X-Rays	Gamma Rays
Range of Wavelengths in Air (m)							
Sources							
Possible Detectors							
Applications							

Check your answers by turning to the Appendix, Section 2: Extra Help.

Enrichment

Do **one** of the following activities.

Visions

1. Do Textbook question 11 from the Think section on page 321 of *Visions 3*.

2. Lasers can produce light that has special properties. These properties can permit lasers to be used as a cutting tool or as a way to transmit digital information. You can learn more about the applications of lasers by reading pages 313 and 314 of your textbook and by listing the details of these applications in your notebook.

Check your answers by turning to the Appendix, Section 2: Enrichment.

Conclusion

In this section you were introduced to the ways that electromagnetic radiation is created, transmitted, and received. You studied three properties of visible light that can be extended to the whole electromagnetic spectrum.

You should now be able to solve mathematical problems relating to the frequency, wavelength, and speed of an electromagnetic wave. You should also be able to describe the basic features of the electromagnetic spectrum and compare and contrast parts of the spectrum.

Assignment Booklet

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 2.

Section

3 Making Choices/ Reducing Risks

JIM WHITMER PHOTOGRAPHY

What do you do when you have to make an important decision? Most people would agree that a good place to start is to find out as much information as possible about the issue. The next step might be to generate options by considering the problem from as many points of view as possible. You might analyse each option in terms of risks and benefits so that you could begin to narrow down your choices. In the end, you'd probably have to consider the values and priorities in your life before you can finally decide.

If this is a reasonably sound model on which to base a good decision, then it follows that the opposite approach would be more likely to result in a bad decision. Being uninformed, having few options, and rapidly making a decision without considering your values would seem to be a certain recipe for disaster.

The focus of this section is to help you to avoid disaster when it comes to ultraviolet radiation and your skin. You will be given the opportunity to gather information, to consider options, and then to reflect upon your values to develop a lifestyle choice about how you will care for your body's largest organ—your skin.

In this section you will learn what risk means. You will then survey the methods used by experts to assess risks, as well as the factors considered by members of the general public when they determine risk. Finally you will apply your knowledge of electromagnetic radiation and risk/benefit analysis to make an informed decision.

Activity 1: What Is Risk?

Do you think that you lead a risky life? Do your friends or your family take risks on a daily basis? To help you organize your thoughts on these questions, complete the following survey about risks taken in daily life.

1. Rank the following hazards in the order of their level of risk to the citizens of Canada. Indicate the hazard with the greatest risk with a 1 and the hazard with the least risk with a 7. There are no right or wrong answers to this question. The idea is to get you thinking about risks.

Hazard	**Rank**
nuclear	______
motor vehicles	______
cigarette smoking	______
non-nuclear power	______
home appliances	______
food preservatives	______
skiing	______

The first thing that you should realize after completing question 1 is that everything has a level of risk associated with it. Risk is an accepted part of life. Even if you spent your whole life in bed and never left your home, you would face the risk of poor health from lack of exercise. However, this does not mean that exposure to each of the hazards listed is inevitable. Many of these require a person to make a lifestyle choice that puts them at a greater risk. Cigarette smoking is a good example of this.

2. Explain why cigarette smoking is banned from public places such as buses and the lobbies of public buildings.

Check your answers by turning to the Appendix, Section 3: Activity 1.

If something as simple as a different lifestyle choice can reduce a person's level of risk, it's natural to wonder why anyone smokes. After all, why not live the less risky alternative?

The answer to this question has to do with the way risk is determined. As you'll discover in the next activities, the methods used to determine risk by members of the general public are very different than the methods used by experts in the field of risk assessment.

Activity 2: Risk Assessment by Experts

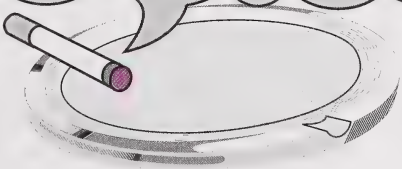
If the proposal was made to build a nuclear power plant within 10 km of your home, expert advice would most certainly be sought.

Experts in the field of risk assessment examine the risks involved with a hazard for the following reasons:

- Risk assessment helps find ways to avoid, reduce, or otherwise manage risks.
- Risk assessment helps illuminate all the aspects of a situation so it can be better understood.
- Risk assessment can be used as a design tool for new technologies. Since the technology is new, no one knows how the whole process will work and how it is likely to break down. Risk assessment can be used to imagine all possible accidents and then design an independent safety device that can be added to each component. This is how nuclear power plants are designed. A total system failure in a nuclear power plant requires many components and their matched safety devices to fail one after the other. Because this is a remote possibility, many experts maintain that major accidents at a nuclear power plants are very unlikely.

You can see from the kinds of things done by those in the field of risk assessment that uncertainty is at the heart of this work. The handling of data to predict uncertainties requires the mathematical techniques of probability and statistics. Statistics is the language of risk assessment. As an example, consider the following statistics which assess the risks from smoking cigarettes.

- Every cigarette that you smoke takes 5 min off your life.
- Thirty percent of all cancers are attributable to cigarette smoking.
- Every cigarette that you smoke increases your chance of death by a factor of 1 in 1.4 million.
- Smoking one pack of cigarettes a day for one year has an associated mortality rate of 3600 deaths in 1 million people.
- People who smoke a pack a day for 50 a will, on average, shorten their life span by 3.5 a.



1. Show that the first and last statistics are consistent with each other by doing a calculation. Note that the statistics are based on 20 cigarettes in one package.

2. Show that the third and fourth statistics are close, but not perfectly consistent with each other, by doing a calculation.

3. If you sat down and quoted these statistics to a person who smoked one pack of cigarettes a day, what would the response likely be? Would more statistics help?

Although many experts feel that risk assessments should be expressed in as many different ways as possible to help deepen the understanding of the problem, the truth of the matter is that the average person may not be able to understand what the statistic really means, especially if the probability is very low.

Some psychologists have suggested that the reason for this is that most people can only understand a range of numbers that are separated by a factor of 10^4. In other words, telling a person that the probability of an event happening is 1 in 10 000 is about the limit of true understanding. Beyond that the meaning is lost.

4. Explain why the statistic that each cigarette increases your chances of death by a factor of 1 in 1.4 million is a meaningless statistic to many people.

Check your answers by turning to the Appendix, Section 3: Activity 2.

You can see that the statistical estimates of risk that are produced by experts in the field of risk assessment can become "just another statistic" to the general public.

The general public uses a different set of strategies to determine risk. Because these strategies are not based on detailed statistical analysis, the result is referred to as a risk perception rather than a risk assessment. Different strategies produce different outcomes in terms of determining risks. You'll learn more about this in the next activity.

Activity 3: Risk Perceptions by the General Public

A perception is an opinion formed in the mind of an observer. When a citizen is asked to determine risk, the result is a risk perception which is based on a judgement of the hazard. What criteria do people use in forming a perception of risk? Psychologists have conducted a number of studies to answer this question. Although the detailed answers that people give will vary from hazard to hazard and from one observer to the next, there are trends in the criteria used to form a perception of risk.

Factors Most Often Used to Form a Risk Perception

Potential for Catastrophe: If the potential exists for killing a large number of people in a very short time, or if the possibility exists for harming future generations, the hazard is perceived to be a high risk.

Degree of Control: If the individual feels that they have little control over the hazard, the hazard is perceived to be a high risk.

Knowledge: If the only knowledge that an individual has of a hazard comes from the media (which tends to focus on mishaps and threats to health), or if the individual feels that the hazard is new, undetectable, and unknown to science, the hazard is perceived to be a high risk.

One way to communicate a risk perception using these factors is to put each factor on a continuum, with the extreme points of view at each end.

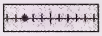
Perceived as Low Risk		Perceived as High Risk
	Potential for Catastrophe	
• affects only individuals • no effects on future generations		• globally catastrophic • future generations affected
	Control over Hazard	
• controllable • voluntary exposure		• uncontrollable • involuntary exposure
	Knowledge of Hazard	
• hazard is known to science • immediate consequences • observable		• unknown to science • negative media coverage • delayed consequences • unobservable

By referring to these factors, it is possible to speculate why the general public judges some things to be of greater risk than others. For example, consider the perception of risk that most people have towards motor vehicles. The continuum that follows represents why most people regard motor vehicles as a relatively safe form of travel.

Perceived as Low Risk — Perceived as High Risk

Potential for Catastrophe

- affects only individuals
- no effects on future generations



- globally catastrophic
- future generations affected

Control over Hazard

- controllable
- voluntary exposure

- uncontrollable
- involuntary exposure

Knowledge of Hazard

- hazard is known to science
- immediate consequences
- observable

- unknown to science
- negative media coverage
- delayed consequences
- unobservable

Since most motor vehicle accidents involve individuals and have no effect on future generations, the potential for catastrophe is low. The matter of control over the hazard may at first seem high because you choose to be in the vehicle and you may even be driving. However, the actions of other drivers add a level of uncontrollability. Virtually everyone has had first-hand experiences with cars. Media coverage is mixed, with positive coverage (car commercials on TV) and negative coverage (accident reports on the news). In this case the knowledge of the hazard tends to favour a low perception of risk.

You can see why motor vehicles might be judged as having a low to moderate risk. However, this perception would not match the numerical risk assessment by the experts who have determined motor vehicles to be among the top three causes of death in Canada. Depending on how the study is done, details will vary, but it is recognized that motor vehicles, cigarette smoking, and the consumption of alcohol are leading causes of death in Canada.

1. Describe a lifestyle that would significantly reduce a person's individual level of risk.

Science Skills
- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☐ D. Analysing
- ☐ E. Synthesizing
- ☑ F. Evaluating

2. Using the previous example as a guide, use the continuums to determine how you think most people would rate non-nuclear electric generating stations as a hazard. Support your answer by explaining each rating. What overall risk would be perceived by the general public?

As with the last case, the experts' numerical risk assessment does not agree with the public perception of risk. Whereas the conventional nature of generating electricity (using known technology) may give people the perception that it is relatively safe, in fact it would rank behind only motor vehicles, cigarette smoking, alcohol consumption, and handguns as the fifth largest cause of death in Canada.

Science Skills
- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☐ D. Analysing
- ☐ E. Synthesizing
- ☑ F. Evaluating

3. Use the previous continuums as guides to determine how you think most people would rate nuclear power plants. Support your answer by explaining each rating. Conclude by speculating on the overall risk perceived by the general public.

Check your answers by turning to the Appendix, Section 3: Activity 3.

Nuclear power is the ultimate example to illustrate the difference in opinion between experts and the general public. From the public's point of view, nuclear power plants have been portrayed as being linked to nuclear weapons and global catastrophe. Mental images of large numbers of people dying and future generations being adversely affected easily come to mind. In addition, fear is generated because people have the perception that an accident would be uncontrollable, causing thousands of people to be exposed. Finally, radiation is perceived as being unobservable and having many consequences that are still unknown to science. The end result is that many people would judge nuclear power to be one of the top hazards to the citizens of Canada.

In sharp contrast, the experts would say that the probability of death from living a lifetime next to a nuclear power plant is the same as driving 120 km in an automobile. Think about what this statistic is saying: it is safer to live a lifetime beside a nuclear power plant than it is to drive from Calgary to Red Deer (145 km)! Statistically, the probabilities are so low that the experts would not even rate nuclear power within the top twenty causes of death in Canada. Yet in the minds of some people, the overwhelming dread of a large scale nuclear accident renders all statistics meaningless, no matter how low the calculated probability is.

This situation goes beyond who's right and who's wrong. In the next activity you will see that the gulf between these points of view has several adverse effects on society.

Activity 4: Risk Assessments Versus Risk Perceptions

Many people think that nuclear power is just the first of a series of new technologies that will cause the general public and experts to be at odds when it comes to determining risks. It's been said that one of the only things you can count on is change. The future will bring many new technologies. It is important for both the experts and the general public to reach common ground when it comes to the management of risk. If both groups maintain the kind of sharp divided opinions that surround the nuclear power issue, there will be several negative consequences for society.

- Citizens will live in a perpetual state of fear about the perceived risks from the hazards in their lives. Although people may live in what many consider to be the richest and most resourceful civilization, the high level of anxiety may seriously detract from the quality of life.

- Economically, the costs to the national economy due to disagreements about risk are enormous. Money spent on lengthy court battles, costly delays, misplaced investments, and retrofits reflect the inability of industry to predict what level of risk will be accepted by the general public.

- Law makers can become paralysed in making public policy because of the radically different expectations of individual special interest groups. Imagine that you are an elected official working to draft new laws related to public safety. On one hand you must answer to citizen groups, who may demand zero risk, which in itself is an impossibility, while on the other hand you need to consider the needs of industry to produce a product or provide a service at a competitive price. Both groups claim that the issue is one of survival and there is no room for compromise. How do you satisfy all these competing viewpoints? Unfortunately, the safest political move is often to make no decision or to refer the problem to a committee and try to offend as few people as possible to ensure re-election. The whole process of drafting the public safety legislation becomes paralysed.

1. How can the previous situation be resolved? List some concrete suggestions that would help.

Check your answers by turning to the Appendix, Section 3: Activity 4.

Perhaps the most important thing is for both sides in the debate to respect the intelligence and the insights of the other side. Experts must not be so arrogant and must not refer to the concerns of the general public as imaginary risks. The general public has a broad concept of risk that includes legitimate concerns that are often left out when experts do their risk assessments. The general public must accept the responsibility of being the decision makers. The public needs to become better informed and also needs to take an active role in finding workable solutions.

Making an Informed Decision

Your role as a decision maker begins right now. You are now a citizen who is informed and educated about the physics of electromagnetic radiation and the nature of risk. You are now ready to play an important role as an informed citizen. In the remainder of this activity you will apply all of your skills.

Science Skills
- ☐ A. Initiating
- ☑ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☑ E. Synthesizing
- ☑ F. Evaluating

You will be given the opportunity to choose one of two positions and you will attempt to make an informed decision on the issue. There are no right or wrong answers, but you must adopt a concrete position. The focus is not on your choice, but on how well you support your choice with clear reasoning that is supported by examples. To help you with this process, you will be asked questions that will help you identify important pieces of information and organize your thoughts.

At the end of this activity you will be asked which of the following opinions you support. You must choose one of these opinions.

Opinion A	Opinion B
People who make questionable lifestyle choices, such as excessive suntanning, should be forced to make extra health care payments. This extra money would help to pay for the extra care and treatment that they may eventually require.	Extra health care payments for people who make questionable lifestyle choices, such as excessive sun tanning, are unfair. Efforts should be made to educate the whole population about which lifestyle choices promote good health.

Science Skills
- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☐ D. Analysing
- ☐ E. Synthesizing
- ☑ F. Evaluating

2. Use the risk perception continuum to determine how you think most people would rate suntanning. Support your answer by explaining each rating. Conclude by speculating on the overall risk perceived by the general public.

Check your answers by turning to the Appendix, Section 3: Activity 4.

The preceding question required you to form a perception of risk the same way that a member of the general public would. However, you learned earlier that it's important to go beyond initial perceptions of risk by gathering information and by considering expert advice.

You can begin this process by reading the pamphlet from the Canadian Dermatology Association entitled *Sun Facts* which can be found at the end of the Appendix for this module. When you have finished reading, answer the following questions.

3. List the three factors that determine who's most at risk for the more prevalent forms of skin cancer.

4. List the three factors that determine who's most at risk for developing malignant melanoma, the less common but more deadly form of skin cancer.

5. List some strategies that are effective at protecting your skin from the sun.

6. Why is the thinning of the ozone layer a concern to dermatologists?

7. Explain how photoaging is different from biological aging.

8. Why is it most important for young children and teenagers to be protected from excessive sun exposure?

Check your answers by turning to the Appendix, Section 3: Activity 4.


[1]

The hazard posed by the sun's ultraviolet rays has been recognized by two departments of the federal government: Environment Canada and Health and Welfare Canada. You can find out about the service provided to Canadians by these departments by reading the article entitled "Ozone Watch rates those harmful rays" from *The Edmonton Journal* which can be found at the end of the Appendix for this module. When you've finished reading, answer the following questions.

9. Which part of the ultraviolet band does the UV index monitor?

10. What does a reading of 10 on the UV index mean?

Of course ultraviolet radiation isn't all bad. It's a part of our natural environment and has benefits as well as risks. You've already read in your textbook how bees use ultraviolet light to guide themselves to the part of a flower containing pollen.

Ultraviolet light also has direct benefits for human beings. You can find out more by reading the article from *The Edmonton Journal* entitled, "Gov't study links ultraviolet light with fewer cavities, better health" which can be found in the Appendix of this module. When you've finished reading this article answer the following questions.

11. List the benefits that appeared in the group of students who were exposed to the ultraviolet light.

12. What oversimplification does the article make about ultraviolet A radiation?

13. Would you expect the children in the group that was exposed to ultraviolet light in the study to be tanned? Explain your answer.

---

[1] *The Edmonton Journal* for the photograph by Larry Wong from May 28, 1992, page C9. Reprinted by permission of *The Edmonton Journal*.

14. How much money could be saved over the four years that it would take to retrofit schools with new lighting that incorporated full spectrum lamps that include UVA light?

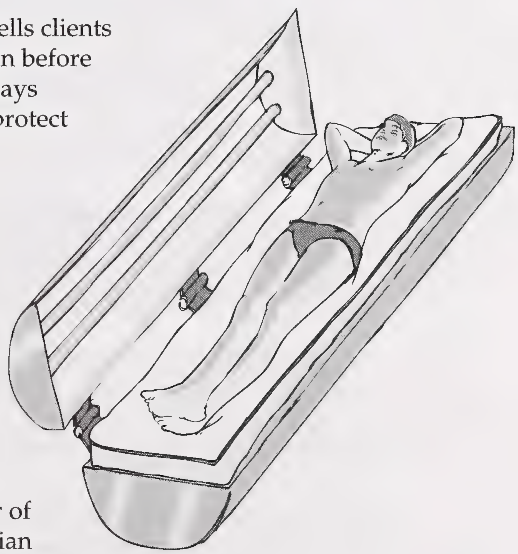
15. Combine the main ideas from this article and the previous one to describe the circumstances in which ultraviolet radiation is beneficial as well as the circumstances in which it is harmful. Conclude your answer with one statement that summarizes your answer.

Check your answers by turning to the Appendix, Section 3: Activity 4.

You should now realize that it's not ultraviolet light itself that's the problem, it's excessive exposure over time that creates the problems. The solution in the minds of some people is to get a tan artificially on a tanning bed at a tanning parlour.

According to the Canadian Cancer Society this is not a sound strategy. You can find out why by reading the two short articles by the Canadian Cancer Society entitled "Artificial Sun" and "Shaking Up Indoor Tanning Myths" found at the end of the Appendix to this module.

16. The operator of one tanning parlour tells clients that they should start working on a tan before heading to tropical countries on holidays because the artificial tan will help to protect them from the tropical sun. Explain how the Canadian Cancer Society would respond to this claim.



17. The owner of a beauty salon was looking to expand the business by including tanning beds as part of the operation. A sales representative from a company that supplies tanning beds explained that tanning beds use special lights that are perfectly safe and do not cause cancer. If the owner of the beauty salon contacted the Canadian Cancer Society to check this claim what would be the likely response?

18. One way to give yourself the appearance of a suntan is to cover your body with a lotion containing special dyes that colour your skin. (Beware—some versions of these creams make you look more orange than tanned!) If you applied this kind of lotion could you assume that you were now protected from getting a sunburn?

Check your answers by turning to the Appendix, Section 3: Activity 4.

You might be surprised to learn that the debate over the safety of artificial tanning does not occur only between medical experts and the tanning bed industry. The city of Edmonton had this discussion reach its council chambers several years ago. To find out the details of this debate read the two articles from *The Edmonton Journal* entitled "City's proposal to get rid of suntan beds burns leasing company" and "Mayor fails to block the 'sun'" which can be found at the end of the Appendix to this module. When you've finished reading, answer the following questions.

19. Speculate on the reasons why Dr. James Howell claims that commercial suntanning goes "against the principles of preventative health."

20. How would the Canadian Dermatological Society and the Canadian Cancer Society assess Mr. Christiansen's defence for the use of suntan beds?

21. The last article suggests that there is no proof of the relationship between tanning booths and skin cancer. How would an experiment have to be designed to either prove or disprove this relationship? Why aren't the results from this kind of an experiment available now?

Check your answers by turning to the Appendix, Section 3: Activity 4.

You may have noticed from the previous article that even though the medical community has a common stand on suntanning, it is clear that people in the general public do not. Opinions between business people, civic politicians, and others can vary greatly when it comes to the level of risk associated with tanning.

An even more difficult question to fathom concerns the benefits of tanning. Even if you adopt the position that all the medical opinions are uncertain and that the risks are being overstated, wouldn't it make sense to avoid tanning—just in case future research proves them right? What drives people to take these risks?

One theory that attempts to answer these questions is presented in the article from *The Edmonton Journal* entitled "Save your hide" which can be found at the end of the Appendix for this module. Read this article and answer the following questions.

22. How does the article explain what motivates people to get a sun tan?

23. Use a dictionary to develop a definition for the word *lifestyle*. How would you define a healthy lifestyle?

24. It's not true that all fashion trends lead to an unhealthy lifestyle. Can you think of one activity that is currently regarded as fashionable, trendy, or cool that leads to a healthier lifestyle?

Check your answers by turning to the Appendix, Section 3: Activity 4.

You should now have a sense of the connection between lifestyle choices and skin cancer. The Alberta Cancer Board would argue that unfortunately most people do not understand this connection very well. You can find out why by reading the article from the Cancer Prevention Annual Report entitled "Prevention: It's In Our Hands" which can be found at the end of the Appendix for this module.

25. List the misconceptions about the causes of cancer held by at least 50% of the population.

26. Explain the statistic that 50% to 60% of cancers could be avoided.

Science Skills
- [ ] A. Initiating
- [x] B. Collecting
- [x] C. Organizing
- [x] D. Analysing
- [x] E. Synthesizing
- [x] F. Evaluating

27. Return to the two opinions expressed at the beginning of this activity. Choose one of these opinions and support it in the form of a well-organized, short essay using information from the sources that you read. Your answer should also explain why you do not support the other opinion.

Check your answers by turning to the Appendix, Section 3: Activity 4.

Follow-up Activities

If you had difficulties understanding the concept in the activities, it recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

1. Construct a chart in your notebook using the headings outlined. You will need to adjust the size of your chart according to the length of your answers. Complete the chart to summarize the key ideas from this module.

COMPARING RISK ASSESSMENT TO RISK PERCEPTION		
	Risk Assessment	**Risk Perception**
Who does it?		
What strategies are used?		
What is the outcome of this process?		

2. Refer to your answer to question 1 to explain why the experts and the general public sometimes have such different opinions about risk.

Check your answers by turning to the Appendix, Section 3: Extra Help.

Enrichment

Choose **one** of the following activities.

1. Suntanning is not the first instance of a fashion trend leading to problems in public health. In the 1940s and 1950s cigarette smoking was promoted by the tobacco industry as a sign of glamour and sophistication—the habit of movie stars and sports heroes. However, recently obtained documents from tobacco companies reveal that some companies knew about the links between cigarette smoking and cancer as early as 1952, even though they publicly claimed that smoking was not a health hazard. Visit your local library and ask the librarian to help you obtain a copy of the article entitled "Process of Denial" from pages C1 and C2 of the July 3, 1994, edition of *The Edmonton Journal*. This article outlines how the tobacco industry tried to privately deal with the risks associated with smoking while publicly claiming that there was no proven risk. The following questions will help you to identify the key points.

   a. Describe the findings of an internal report by Batco (British-American Tobacco Company) produced in 1957.

   b. How did the policy of denying there was any connection between cigarette smoking and cancer eventually put the tobacco industry in an impossible position?

   c. Why was the tobacco industry not successful in producing a safe cigarette?

   d. Why do you think the tobacco industry continues to produce a product that it knows is harmful?

2. In this section you have examined the risks and benefits associated with ultraviolet radiation for the purposes of suntanning. Another region of the electromagnetic spectrum that is receiving critical attention is the band that has an extremely low-frequency (ELF). This radiation is emitted by nearly every device that passes a 50 or 60 Hz alternating current.

   You can find out more about the health risks associated with this type of radiation by reading the article on page 302 and by examining the tables on page 303 of *Visions 3*.

   a. Why are two sets of values used to describe the exposures to ELF radiation?

   b. Which source exposes the user to the strongest fields: a 500 000 V transmission line measured at the edge of the right of way or an electric blanket measured as used?

   c. Why is it so difficult to scientifically prove a link between ELF and the health problems of people?

Check your answers by turning to the Appendix, Section 3: Enrichment.

Conclusion

In this section you've seen that there are different ways to determine the risks associated with a particular hazard. These different approaches often produce opinions that differ when it comes to determining the risks involved. As a citizen it is your role to be well informed and to take an active role in the democratic process of determining what level of risk will be acceptable to your community.

Assignment Booklet

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 3.

MODULE SUMMARY

You began this module by reading about a typical day that involved many devices that operated using the principles of electromagnetism. Now that you have finished this module, you should have a better understanding of things like motors and transformers, as well a clear sense of how the whole electromagnetic spectrum impacts upon the events of day-to-day life.

You should also understand that the word *radiation* refers to a wide range of phenomenon. Many of these are harmless and very useful while others require careful monitoring if they are to be utilized safely. The risks and benefits of these electromagnetic waves need to be analysed carefully when you make decisions about using related technology or when you make choices about what role these things will play in your lifestyle.

Appendix

Glossary

Suggested Answers

Articles

Glossary

carrier frequency: the frequency used to carry a communication signal

critical angle: incident angle in a slow medium for which the angle in the fast medium is 90°

domains: groups of neighbouring atoms that produce magnetic fields that align in the same direction

electromagnet: a series of current-carrying coils that produces a magnetic field similar to a bar magnet

electromagnetic induction: a current induced in a coil when the strength of the magnetic field within the coil changes

electromagnetic radiation: energy carried by electromagnetic waves through space

electromagnetic spectrum: the complete range of electromagnetic waves ordered according to frequency or wavelength

electromagnetic wave: a wave of changing electric and magnetic fields that travels through space

gamma rays: electromagnetic radiation with frequencies of 5×10^{19} Hz or higher that comes from the unstable nuclei of radioactive materials

induced current: a current created through electromagnetic induction

infrared radiation: electromagnetic radiation with a frequency range of about 10^{12} Hz to 10^{14} Hz used mainly for transferring and detecting thermal energy

ionosphere: an upper layer of the atmosphere containing charged particles

left-hand rule for coils: a rule that shows the direction of the magnetic field inside a coil that is passing a flow of electrons

left-hand rule for conductors: a rule that shows the direction of the magnetic field around a conductor using electron flow

left-hand rule for force: a rule that shows the direction of the magnetic force acting on negative charges moving perpendicularly through a magnetic field

microwaves: electromagnetic radiation with a frequency range of about 10^{8} Hz to 10^{12} Hz used for cooking, radar, and satellite telecommunication

motor principle: a magnetic force is exerted on a current-carrying wire that is placed at right angles to a magnetic field

polarization: causing a wave to travel in one plane

radio waves: electromagnetic radiation with a frequency range of 100 kHz to 500 MHz used mainly for communications

refraction: the bending of a wave due to a sudden change in the medium in which it travels

risk assessment: a formal statistical evaluation of the risks associated with a hazard expressed by an expert
Risk assessments usually are expressed as a probability with an accompanying uncertainty.

risk perception: an informal judgement of the risks associated with a hazard expressed by the general public
Risk perceptions are opinions that exist in the mind of the observer.

transformer: a device for increasing or decreasing AC voltage

total internal reflection: occurs when light attempts to pass from a slower medium into a faster medium at an angle greater than the critical angle

ultraviolet light: electromagnetic radiation with a frequency range of about 8×10^{14} Hz to 3×10^{17} Hz that is responsible for suntanning

visible light: electromagnetic radiation that can be detected by the human eye

x-rays: electromagnetic radiation with a frequency range of about 3×10^{17} Hz to 5×10^{19} Hz used mainly for medical diagnosis

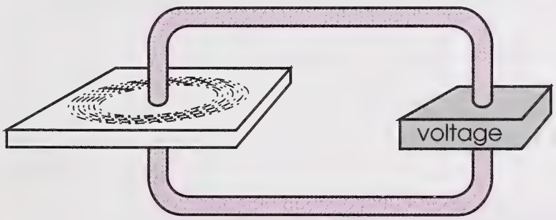
Suggested Answers

Section 1: Activity 1

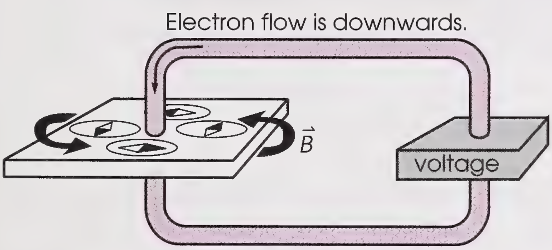
1. Both exert attractive forces over a distance.

2. Hans Christian Oersted attempted to prove that electricity and magnetism were not related.

3. When Oersted placed the compass needle parallel to the conductor that was carrying electrons, the compass needle deflected. This observation suggested that electricity and magnetism are related.

4. 

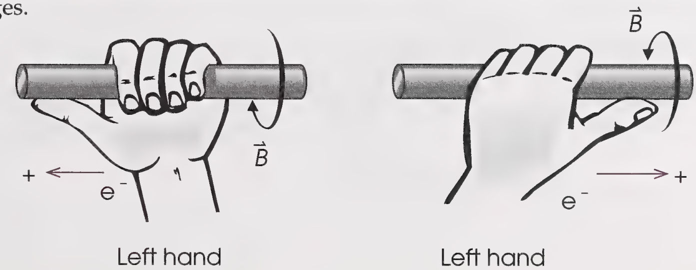
The iron filings form concentric circles around the current-carrying wire.

5. 

The magnetic field is counterclockwise.

6. The shape of the magnetic field remains the same when the direction of electron flow is reversed. Only the direction of the magnetic field changes.

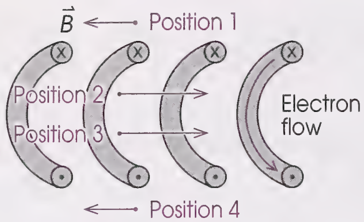
7. Left-hand rule for electron flow:



8. When a switch is opened in a circuit, the magnetic field collapses.

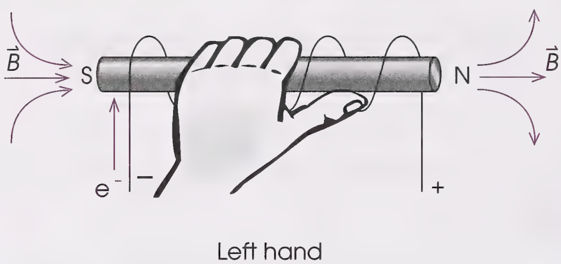
9. The symbol ⊙ is used to represent the direction straight out towards you and the symbol ⊗ is used to represent the direction away from you. This can be used to communicate the direction of magnetic field lines or electron flow.

10.



11. The magnetic field strength is stronger inside the coils because the magnetic field lines are more concentrated and because the field lines from the top of the coil reinforce those at the bottom.

12.



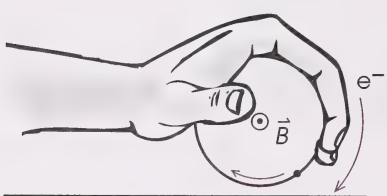
The thumb points towards the north pole and shows the direction of $\vec{B}$ within the coil.

13.

COMPARING PERMANENT BAR MAGNETS TO ELECTROMAGNETS	
Two Similarities	**Two Differences**
Both objects have a north pole and a south pole.	The $\vec{B}$ for a bar magnet exists continually.
Both objects can attract things made of iron, cobalt, and nickel.	The $\vec{B}$ for an electromagnet exists only as long as there is charge flow through the coil.

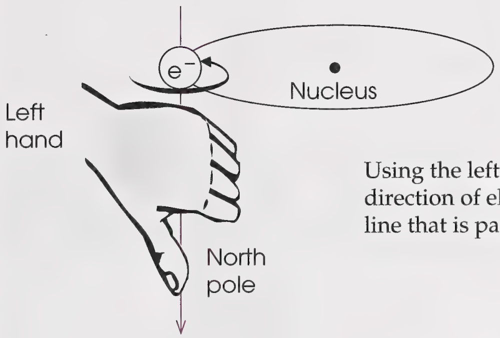
14. When an iron core is inserted into the coils of an electromagnet, the magnetic field strength is increased.

15.



Using the left-hand rule for electron motion, your fingers point in the direction of electron motion and your thumb points in the direction of the north pole, which is out of the plane of the page.

16.



Using the left-hand rule for electron motion, your fingers point in the direction of electron motion and your thumb points downwards along a line that is parallel to the plane of the page.

17. The random motion of electrons around the nucleus of an atom generates magnetic fields which cancel each other out.

18. Iron displays a net magnetic field because within its atomic structure four more electrons spin in one direction than in another direction.

19. The three ferromagnetic substances which display a net magnetic field are iron, nickel, and cobalt.

20. The magnetic dipoles are also thought of as tiny compass needles pointing north.

21. The term given to a cluster of dipoles which point in the same direction is *domain*.

22. The magnetic field strength is increased when an iron bar is inserted into the coils of an electromagnet because the domains within the iron bar align in the same direction as the magnetic field of the electromagnet.

23. When current no longer flows through the electromagnet, the domains return to a random order.

24. The substance added to iron to prevent the domains from a random arrangement is carbon.

25. The poles on a broken permanent magnet would look like this.

26. A permanent bar magnet can be destroyed by heating or by vibration. Both cause the domains to break free of their alignment.

27. Devices like the telephone, microphone, and loudspeakers use the principles described by the hand rules.

28. Ampère knew that the reason that two magnets attract one another was because the magnetic field of one magnet interacted with the other. Ampère's experiment simply replaced each of the magnets with a long wire carrying an electric current. Because each wire creates a magnetic field, as described by the left hand rule for conductors, the two wires should attract one another as magnets do.

29. a. This device is called a rail gun.

    b. The rails much each be carrying a flow of charge, but the charge must move in opposite directions within each rail.

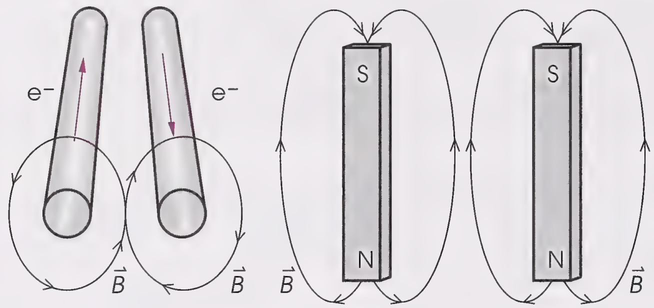
    c. The projectile is a conductor that is designed to allow the charge to pass from one rail to the other.

    d. The rails will strongly repel one another.

30. a. When the electrons flow in the same direction in both wires, the wires attract.

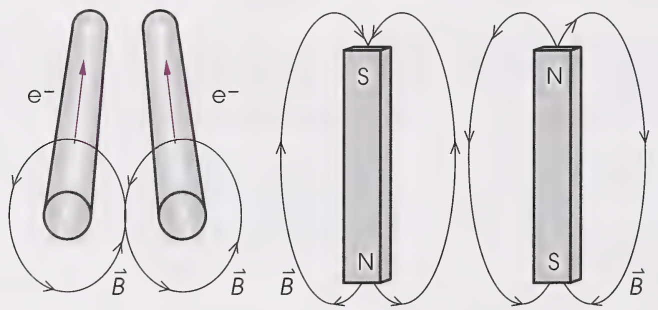
    b. When the electrons flow in opposite directions in the wires, the wires repel.

    c.



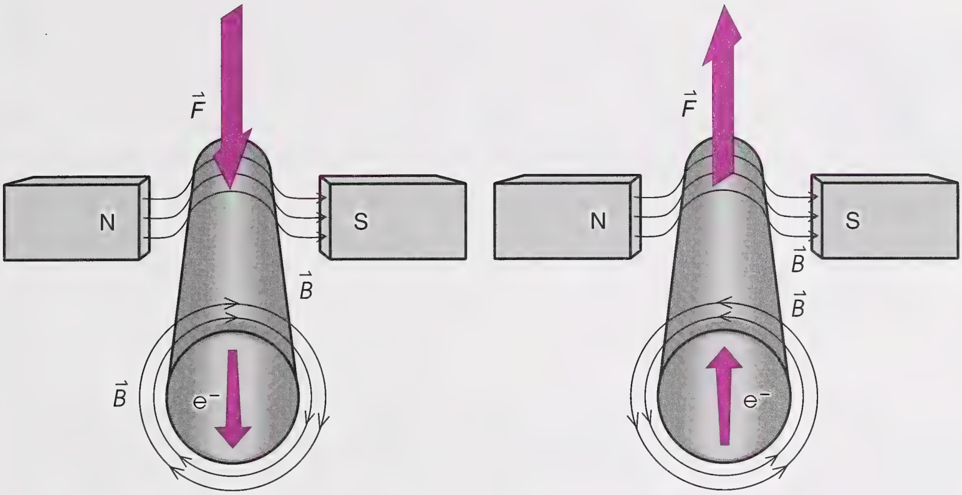
    d. In both cases the magnetic field lines flow in the same direction in the region between the objects. Because the magnets repel each other, this suggests that the wires should also repel.

    e.

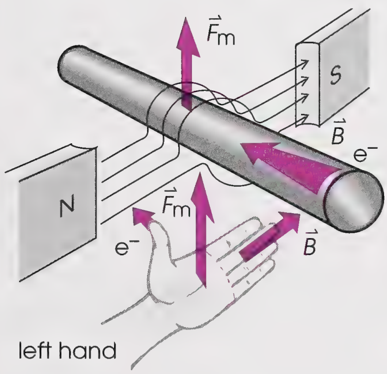


    f. In both cases the field lines run in opposite directions in the region between the objects. Because the magnets attract each other, this suggests that the wires should also attract.

31.

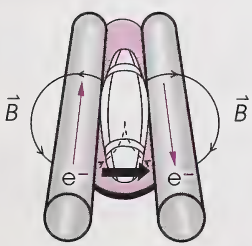


32.



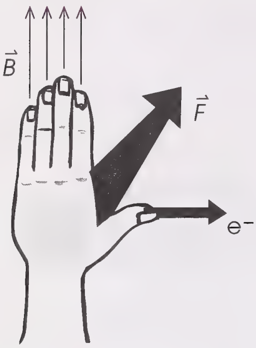
33. The motor principle gets its name because the first application of this idea was in the design of electric motors.

34.



35. This question is answered on the diagram for question 34. Note the bold arrow between the rails.

36.



As shown in the accompanying sketch, the correct application of the left-hand rule for forces predicts that the projectile should be forced away from you, down the rails.

Section 1: Activity 2

1. a. If the magnet is brought closer to the loop, then the loop spins faster on its axis.

   b. The speed increases due to a stronger magnetic field.

   c. The same poles must be together if both magnets are on the same side.

   d. Opposite poles must be closest to the loop if the magnets are on opposite sides of the armature.

2. Answers to this question will vary. Although any of the adjustments mentioned in the module could be listed, the most common adjustment would involve making the ends of the wire straight so that the loop can turn without wobbles. Also making sure that the lacquer is completely removed from one side of the ends of the armature wire, adjusting the position of the magnet, or using two magnets may have been significant as well.

3. Both electric motors are designed to produce a rotational effect on a current-carrying loop within a region of a strong magnetic field.

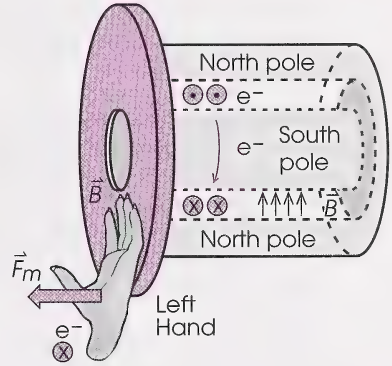
4. The split-ring commutator allows the direction of charge flow to reverse itself every half cycle. This allows the current-carrying loops to continue to spin. The brushes provide contact and a conducting path between the voltage supply and the split-ring commutator. Since the split-ring commutator is continually turning, the brushes must be designed to maintain contact on this moving curved surface.

   The simple motor built in the previous investigation used the fact that the wire was only bare on one side of each of the wire ends of the loop to perform a function similar to a split-ring commutator.

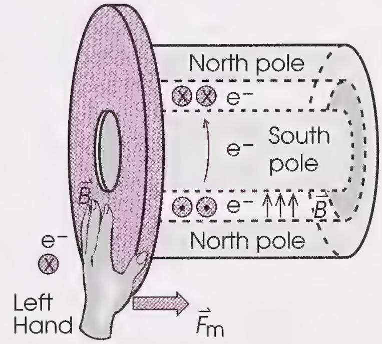
5. a. This question can be answered using the left hand rule for force. In Step 1 the thicker part of the loop will experience an upward force, while in Step 3 the thicker part of the loop experiences a downward force. The overall effect of these two forces is to cause the loop to rotate. At Steps 2 and 4 the forces are still directed up and down, which does not add to the rotation.

   b. The forces on the loop in Steps 2 and 4 do not add to the rotation, but the inertia of the loop causes it to move past these positions anyway. Once the loop has moved past the vertical position, the split-ring commutator reverses the direction of the current, which creates forces that cause the rotation to continue.

6. The diaphragm will be pushed away from the permanent magnet. This is a consequence of the left-hand rule for force applied to the electrons flowing through the coil that is attached to the diaphragm.



7. The diaphragm will be pulled towards the permanent magnet. This is a consequence of the left-hand rule for force applied to the electrons flowing through the coil that is attached to the diaphragm.



8. The diaphragm would vibrate back and forth with a frequency of 250 Hz. This would set up sound waves that would have a frequency of 250 Hz.

9. It is more accurate to say that the magnetic coding is rearranged. During recording, the metal on the tape is organized into aligned domains in certain regions. A large external magnetic field would realign those domains, effectively destroying the information.

Section 1: Activity 3

1. As the magnet was thrust into the coil, a tiny current was created in the coil. This current quickly rose to a maximum value and then it subsided once the magnet stopped moving in the coil.

2. As the magnet sits motionless in the coil the current reading remains at zero.

3. As the bar magnet is quickly removed from the coil, the current readings quickly rose to a maximum value and then subsided once the magnet was clear of the coil.

   It should be noted that the current readings in this case should indicate that the current flows in the opposite direction here to the direction that it flowed for the answer to question 1. In other words, if the current values reached a high positive value in question 1, then they reached a high negative value in question 3.

4. Current readings were observed when the magnet was either pushed into the coil or pulled out of the coil. The current reading was zero when the magnet was left inside the coil or when the magnet was left outside the coil.

   Another way to answer this question is in terms of the magnetic field within the coil. When the magnetic field within the coil was increasing (the magnet was pushed in) a current reading was observed. When the magnetic field within the coil was decreasing (the magnet was pulled out) the opposite current reading was observed.

5. When the power supply was disconnected from the primary coil, the current through the secondary coil surged to a maximum value and then it quickly subsided.

6. When the power supply was reconnected to the primary coil, the current through the secondary coil surged to a maximum value and then it quickly subsided.

   It should be noted that the situation described in this answer is not completely identical to the one described in the previous answer. You should have noticed that in one case the current values surge to a positive value while in the other they surge to a negative value.

7. A steady current through the primary coil produces a zero current reading through the secondary coil.

8. The magnetic field that flowed through the loose-leaf ring was created by the current in the primary coil. When this current was changed by connecting and disconnecting the power supply the resulting magnetic field through the loose-leaf ring changed.

9. The steel loose-leaf ring acted to concentrate the magnetic field lines through both coils.

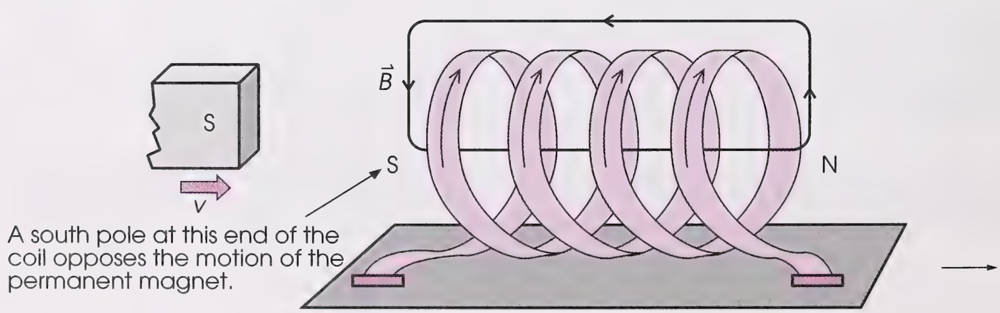
10. A current is observed in the secondary coil when the current through the primary coil changed or alternatively when the magnetic field through the secondary coil changed.

11. a. battery
    b. primary coil
    c. iron ring
    d. secondary coil
    e. galvanometer or multimeter

12. The device shown in question 11 is called a transformer.

13. An induced magnetic field always opposes the change in the magnetic field that creates that induced field.

14. Remember to use the induced electron current for this question.



15. a. The diagram represents a simple electric generator.

    b. The device between the poles of the magnet is called the armature.

    c. An alternating current is induced in the wire leads as the armature rotates. As the armature turns, it moves through an external magnetic field to generate an induced electron flow and an induced magnetic field. According to Lenz's law, an induced magnetic field will appear so that it opposes the motion which creates it, so as the armature rotates from one magnetic pole to the next, its induced magnetic field must switch directions. This results in a switch in the direction of the electron flow within the coils of the armature.

16. a. generator
    b. microphone
    c. earphones
    d. motor

17. You can use your earphones as a microphone. They have a similar construction, so they will function the same.

    - earphone: An electric current causes a coil to become a magnet moving in an external field. The diaphragm vibrates and produces a sound wave.

    - microphone: A sound wave causes the diaphragm to move. A coil attached to the diaphragm moves in an external field which induces an electric current in the coil.

    You can try this idea yourself. If you have access to a tape recorder or a stereo that has a microphone jack, try using a set of headphones in place of the microphone.

18. **Textbook question 3:** An electric motor converts electric energy to mechanical energy while the electric generator converts mechanical energy to electric energy. These devices are very similar in that each one depends on the changing magnetic field strength within the coils of the armature to accomplish the energy transformation.

    Textbook question 5: When electrical energy is distributed with an AC system there is a convenient way to increase or decrease the voltage at each end of a transmission line using a transformer. This means that the electric energy can be transmitted with fewer losses because the heating due to high currents can be kept to a minimum.

    DC systems cannot use transformers because transformers are AC devices. This means that DC systems are forced to use the same safe low voltage for transmission that would be used by the consumer. This in turn means that the electric energy must be transmitted with higher current values and greater heat losses.

19. A step-up transformer is one in which the voltage is stepped up from a low value on the primary coil to a high value on the secondary coil.

20. The trend in the data is that the ratio of the voltages equals the ratio of the number of turns.

Voltage across the primary coil → V_p	$$\boxed{\frac{V_p}{V_s} = \frac{N_p}{N_s}}$$	N_p ← Number of turns on the primary coil
Voltage across the secondary coil → V_s		N_s ← Number of turns on the secondary coil

The following calculations show that this works for each of the transformers illustrated. You may want to try dividing each pair of ratios to see that each fraction does reduce to the same value.

Power Plant Transformer	Substation Transformer	Power Pole Transformer	AC Adaptor (Transformer)
$\frac{V_p}{V_s} = \frac{N_p}{N_s}$	$\frac{V_p}{V_s} = \frac{N_p}{N_s}$	$\frac{V_p}{V_s} = \frac{N_p}{N_s}$	$\frac{V_p}{V_s} = \frac{N_p}{N_s}$
$\frac{6000\text{ V}}{150\,000\text{ V}} = \frac{2000}{50\,000}$	$\frac{150\,000\text{ V}}{2400\text{ V}} = \frac{62\,500}{1000}$	$\frac{2400\text{ V}}{120\text{ V}} = \frac{1000}{50}$	$\frac{120\text{ V}}{9.0\text{ V}} = \frac{400}{30}$

21. Efficiency requires that the output energy be compared to the input energy as shown in the following equation:

$$\boxed{\text{Efficiency} = \frac{\text{Output Energy}}{\text{Input Energy}} \times 100\%}$$

Although electric energy can be difficult to measure, electric power is not. Electric power can be calculated using voltage and current measurements. The following equations show this relationship:

$$
\begin{aligned}
P &= \frac{E}{t} \\
E &= Pt \\
&= VIt
\end{aligned}
$$

Since the time interval (t) would be the same for the input and output energy determination, this time would cancel from the calculation of efficiency as shown in the following analysis:

$$
\begin{aligned}
\text{Efficiency} &= \frac{E_{\text{out}}}{E_{\text{in}}} \times 100\% \\
&= \frac{E_{\text{secondary}}}{E_{\text{primary}}} \times 100\% \\
&= \frac{V_s I_s t}{V_p I_p t} \times 100\%
\end{aligned}
$$

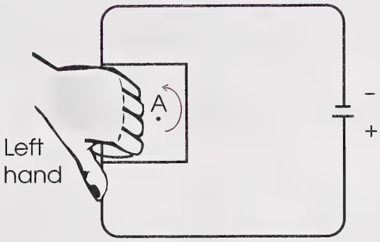
$$\boxed{\text{Efficiency} = \frac{V_s I_s}{V_p I_p} \times 100\%}$$

It follows from this analysis that the current values for the primary and secondary coils would need to be determined to calculate the efficiency. Because these measurements should only be done by professionals, electrical engineers would need to be consulted for the specifications.

Section 1: Follow-up Activities

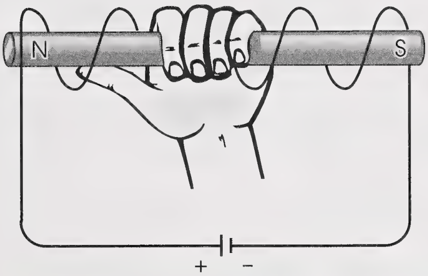
Extra Help

1.



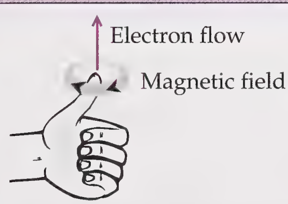
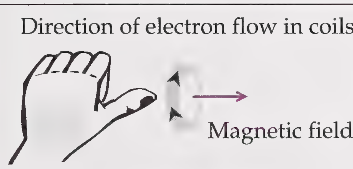
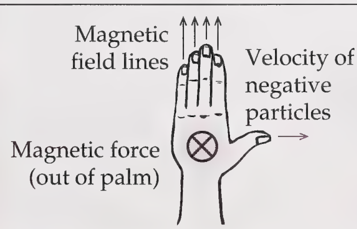
The left-hand rule for conductors indicates that the magnetic field would be directed away from you or into the plane of the page at point A.

2.



When using the left-hand rule for coils, your fingers point in the direction of electron flow and your thumb points toward the north pole, which is on the left side of the electromagnet.

3.

Rule™	Variables
Left-hand Rule for Conductors	
Left-hand Rule for Coils	
Left-hand Rule for Force	

Enrichment

1. a. Using the left-hand rule for force, the electrons should be deflected vertically up towards the top of the screen.

   b. Turning on the oscilloscope should verify your prediction. If you get different results, check that you are using your left hand and that the magnets have the correct polarity.

   c. In each case, proper application of the left-hand rule should predict the results demonstrated by the oscilloscope.

2. a. There is some thought that PCBs may contain small amounts of deadly impurities that become reactive when heated and that have been linked to some forms of cancer. This being so, federal regulations to prohibit the manufacture of transformers containing PCBs were put in place in 1980. Newer transformers use other liquids with properties similar to PCBs, but which have not yet been linked to cancer. Unfortunately, many of these other liquids are more toxic than PCBs and represent other dangers if you are exposed to them.

   b. Transformers contain transformer oil that can be toxic. When taking apart a transformer, it is almost impossible to not come in contact with the oil. It is also necessary to store the oil properly, something that you are probably not equipped to do.

Section 2: Activity 1

1. When the motor is off there is no interference with the radio signal, so the motor must be responsible.

2. A motor consists of a coil of wire wound around a metal rod to form the armature. Current is made to flow through the coil. This is similar to a coil made of wire wrapped around a metal rod or bolt.

3. A clicking sound is heard whenever the current flow is interrupted.

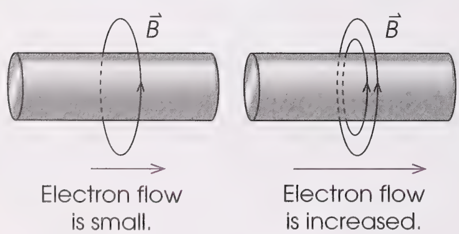
4. The clicking sound is very difficult to detect when the coil is not part of the circuit.

5. It was the changing magnetic field lines from the primary coil that induced the current in the secondary coil.

6. The changing magnetic field lines from the coil somehow enabled the coil to influence the radio.

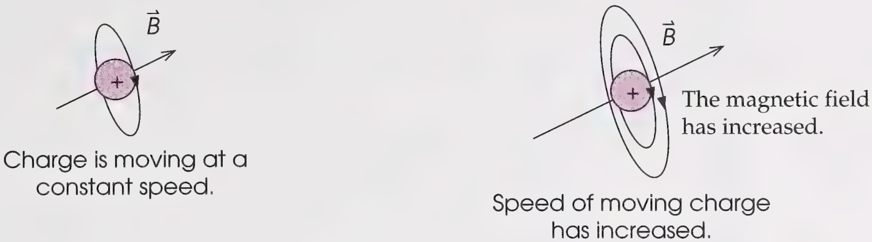
7. No, there is no iron or steel core that links both the coil and the radio.

8. Following the line of thought suggested by the previous questions, it would appear that radio waves somehow include or are affected by changing magnetic fields.

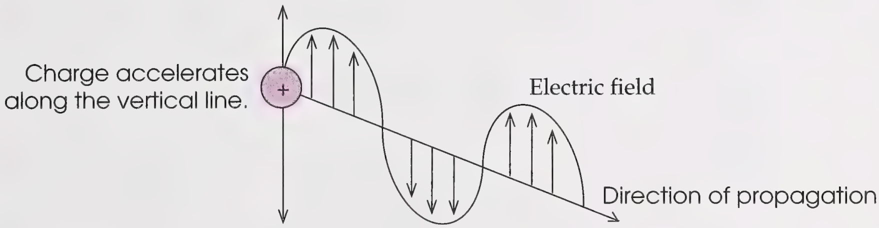
9. 

10. A changing magnetic field would create a changing electric field, which could cause a current to flow.

11.



12.



13. a. transformer b. terminals

14. The transformer acts to step up the voltage, and the terminals allow a spark to oscillate in the space between them.

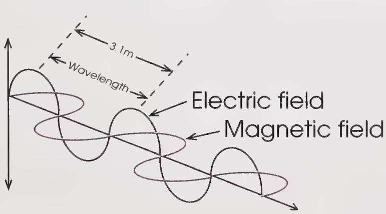
15. Hertz used a wire loop with a gap in it to act as a detector. Sparking at the gap indicated reception of an electromagnetic wave.

16. The list of wavelengths from longest to shortest follows: radio waves, microwaves, infrared radiation, visible light, ultraviolet light, x-rays, and gamma rays.

17. The receiving coil only responds to the electric field component of the electromagnetic wave. Because the initial sparks were vertical, the electric field would be vertical and the receiving coil would also have to be vertical. In other words, all of these things would have to be parallel to each other—or in the same plane.

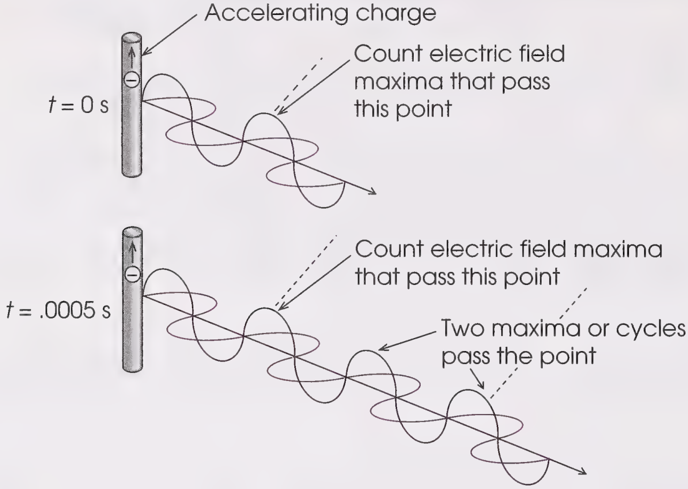
18. Hertz's discovery confirmed Maxwell's prediction that light was just one type of many possible forms of electromagnetic radiation.

19. a. The wavelength of an electromagnetic wave is measured from one electric field maximum to the next. The following diagram illustrates this idea.



The wavelength of this electromagnetic wave would be 3.1 m.

b. The frequency of an electromagnetic wave is determined by how frequently the accelerating charge that starts the wave vibrates back and forth. The frequency of the wave is measured by counting the number of complete vibrations of the source charge that occur in one second. Frequency could also be measured by counting the number of electric field maxima that pass a stationary point in one second. In terms of the wave this is the number of complete cycles passing a stationary point in one second.



$$\begin{aligned}\text{frequency} &= \frac{\text{Number of cycles}}{\text{time}}\\ &= \frac{2\text{ cycles}}{0.0005\text{ s}}\\ &= 4000\text{ cycles/s}\\ &= 4000\text{ Hz}\end{aligned}$$

20. Speed of the electromagnetic wave (m/s) → $\boxed{c = \lambda f}$ ← Frequency of the electromagnetic wave $\left(\frac{\text{cycles}}{\text{s}} = \text{Hz}\right)$

↑ Wavelength of the electromagnetic wave (m)

21. a. Red light

$f = 4.8 \times 10^{14}$ Hz

$c = 3.00 \times 10^{8}$ m/s

$\lambda = ?$

$$\begin{aligned}c &= f\lambda\\ \lambda &= \frac{c}{f}\\ &= \frac{3.00\times 10^{8}\text{ m/s}}{4.8\times 10^{14}\text{ Hz}}\\ &= 6.3\times 10^{-7}\text{ m}\end{aligned}$$

AM Radio Waves

$f = 740 \text{ kHz} = 740 \times 10^3 \text{ Hz}$

$c = 3.00 \times 10^8 \text{ m/s}$

$\lambda = ?$

$$c = f\lambda$$
$$\lambda = \frac{c}{f}$$
$$= \frac{3.00 \times 10^8 \text{ m/s}}{740 \times 10^3 \text{ Hz}}$$
$$= 405 \text{ m}$$

b. The wavelength of red light is much shorter than the wavelength of police radar, while the wavelength of AM radio waves is much longer.

c. The red light from the police laser has a much shorter wavelength than the radar that the detector is designed to receive.

22. **Textbook question 1:**

$f = 800 \text{ MHz}$
$= 800 \times 10^6 \text{ Hz}$
$= 8.00 \times 10^8 \text{ Hz}$

$c = 3.00 \times 10^8 \text{ m/s}$

$\lambda = ?$

$$c = \lambda f$$
$$\lambda = \frac{c}{f}$$
$$= \frac{3.00 \times 10^8 \text{ m/s}}{8.00 \times 10^8 \text{ Hz}}$$
$$= 0.375 \text{ m}$$

Textbook question 2:

$\lambda = 390 \text{ m}$

$c = 3.00 \times 10^8 \text{ m/s}$

$f = ?$

$$c = \lambda f$$
$$f = \frac{c}{\lambda}$$
$$= \frac{3.00 \times 10^8 \text{ m/s}}{390 \text{ m}}$$
$$= 7.69 \times 10^5 \text{ 1/s}$$
$$= 7.69 \times 10^5 \text{ Hz}$$

Textbook question 3:

$f = 102.1 \text{ MHz}$
$= 102.1 \times 10^6 \text{ Hz}$
$= 1.021 \times 10^8 \text{ Hz}$

$c = 3.00 \times 10^8 \text{ m/s}$

$\lambda = ?$

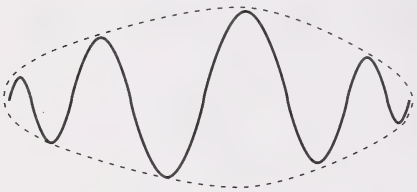
$$c = \lambda f$$
$$\lambda = \frac{c}{f}$$
$$= \frac{3.00 \times 10^8 \text{ m/s}}{1.021 \times 10^8 \text{ Hz}}$$
$$= 2.94 \text{ m}$$

Section 2: Activity 2

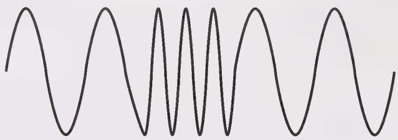
1. The source of all electromagnetic waves is an accelerating charge. As long as the electrons in the antenna are vibrating back and forth they are accelerating (speeding up and slowing down) and creating electromagnetic waves.

2. AM waves have the signal coded in the amplitude. To do this the amplitude is modulated or changed. FM waves have the signal coded in the frequency. To accomplish this the frequency is modulated.

AM Radio Waves



FM Radio Waves



3. $f_1 = 88 \text{ MHz} = 88 \times 10^6 \text{ Hz}$

$f_2 = 108 \text{ MHz} = 108 \times 10^6 \text{ Hz}$

$c = 3.00 \times 10^8 \text{ m/s}$

$\lambda_1 = ?$

$\lambda_2 = ?$

$$c = f\lambda$$
$$\lambda_1 = \frac{c}{f_1} = \frac{3.00 \times 10^8 \text{ m/s}}{88 \times 10^6 \text{ Hz}} = 3.4 \text{ m}$$

$$c = f\lambda$$
$$\lambda_2 = \frac{c}{f_2} = \frac{3.00 \times 10^8 \text{ m/s}}{108 \times 10^6 \text{ Hz}} = 2.78 \text{ m}$$

4. $f = 2.45 \times 10^9 \text{ Hz}$

$c = 3.00 \times 10^8 \text{ m/s}$

$\lambda = ?$

$$c = f\lambda$$
$$\lambda = \frac{c}{f} = \frac{3.00 \times 10^8 \text{ m/s}}{2.45 \times 10^9 \text{ Hz}} = 0.122 \text{ m} = 12.2 \text{ cm}$$

5. A researcher who was working on a radar wave guide by chance had a chocolate bar in his pocket as he was making adjustments. The radar radiation melted his chocolate bar.

6. The metal screen has holes that are much smaller than the wavelength of the microwaves within the oven. This is a safety feature to keep the microwaves in the oven because if they escaped they could cause tissue damage such as cataracts.

7. When people are lost at sea or in dense bush, their own infrared emissions may be the only source of heat in such harsh environments. This would help rescuers identify them from search aircraft (even at night) using specialized infrared detectors.

8. $f_1 = 1\times10^{12}$ Hz

$f_2 = 1\times10^{14}$ Hz

$c = 3.00\times10^{8}$ m/s

$\lambda_1 = ?$

$\lambda_2 = ?$

$$c = f\lambda$$
$$\lambda_1 = \frac{c}{f_1} = \frac{3.00\times10^{8}\ \text{m/s}}{1\times10^{12}\ \text{Hz}} = 3\times10^{-4}\ \text{m}$$

$$c = f\lambda$$
$$\lambda_2 = \frac{c}{f_2} = \frac{3.00\times10^{8}\ \text{m/s}}{1\times10^{14}\ \text{Hz}} = 3\times10^{-6}\ \text{m}$$

9. Mosquitoes can sense infrared radiation and they use this sense to locate blood meals in warm-blooded animals. When you stand next to a source of thermal energy, the infrared radiation emitted by your body would be very hard to detect (just as it would be hard to see a light on an aircraft that was flying close to the position of the sun in the sky).

10. a. $\lambda = 6.6\times10^{-7}$ m

$c = 3.00\times10^{8}$ m/s

$f = ?$

$$c = \lambda f$$
$$f = \frac{c}{\lambda} = \frac{3.00\times10^{8}\ \text{m/s}}{6.6\times10^{-7}\ \text{m}} = 4.5\times10^{14}\ \text{Hz}$$

b. $\lambda = 4.8\times10^{-7}$ m

$c = 3.00\times10^{8}$ m/s

$f = ?$

$$c = \lambda f$$
$$f = \frac{c}{\lambda} = \frac{3.00\times10^{8}\ \text{m/s}}{4.8\times10^{-7}\ \text{m}} = 6.3\times10^{14}\ \text{Hz}$$

11. The scientists realized that as the ozone layer got thinner, there would be an increase in the intensity of the ultraviolet light at Earth's surface and therefore an increase in the risk of skin cancer and other skin problems.

12. X-rays are produced when electrons suddenly lose energy. Medical x-ray machines do this by first accelerating electrons to high speeds and then by rapidly decelerating them as they collide with a metal target.

13. The screen contains lead to shield the viewers from the x-rays that would be created when the electrons are stopped by the special coating on the inside of the screen.

14. The fact that this procedure is nonsurgical and that it can be done relatively quickly means that there is less trauma to the patient.

15. Fetuses and infants are in a stage of rapid growth and development. Because this implies a very high rate of cell division, they are very vulnerable to the effects of ionizing radiation.

16. As explained in the answer to the previous question, the unborn baby is very vulnerable to x-ray radiation.

17. All of the waves in the electromagnetic spectrum are types of electromagnetic radiation. Visible light is a form of radiation that is the basis for all life on the planet. Without photosynthesis, life could not exist as you know it. When you sit close to a friend and feel the warmth of his or her body, you are really detecting the infrared radiation of that person's body. Listening to an FM radio station requires you and your radio to be surrounded by the radiations from the radio station's antenna. Clearly the word *radiation* applies to a wide variety of phenomena, most of which are either essential or desired in everyday living.

18. Remote sensing technology can be applied to the following tasks: searching for natural resources in the Arctic and East Coast, all-weather environmental surveillance to keep track of sea conditions (wave height) in shipping lanes, and the monitoring of the flow of icebergs and pack ice through shipping lanes. The monitoring of sea ice is particularly important to energy exploration in the north. Remote sensing can also improve weather forecasting.

19. Synthetic aperture radar (SAR) is microwave radiation with a frequency range of 1.5×10^{9} to 1.0×10^{10} Hz or 1.5 to 10 GHz (wavelength is 3 cm to 20 cm). The satellite bounces this radiation off Earth's surface and then maps the strength of the return signal. The images provide information about the topography of Earth (slope of the land) as well as information about the roughness of Earth's surface—calm water is smooth while trees are rough.

    An optical sensor is used to detect infrared and visible radiation from Earth's surface. The visible band consists of the visible spectrum $\left(\lambda = 4.0 \times 10^{-7}\text{ m to } 7.0 \times 10^{-7}\text{ m}\right)$ while the infrared range involves wavelengths between 3×10^{-4} m to 7×10^{-7} m. The optical sensor is capable of enabling the user to distinguish between different types of vegetation as well as topographical information.

    The final sensor that is used is called a scatterometer. This sensor uses microwave radiation with frequencies slightly higher than 10 GHz. The radar radiation in this case is very sensitive to waves induced on the surface of water by winds, so it can provide valuable information about wind speed and direction for weather forecasts.

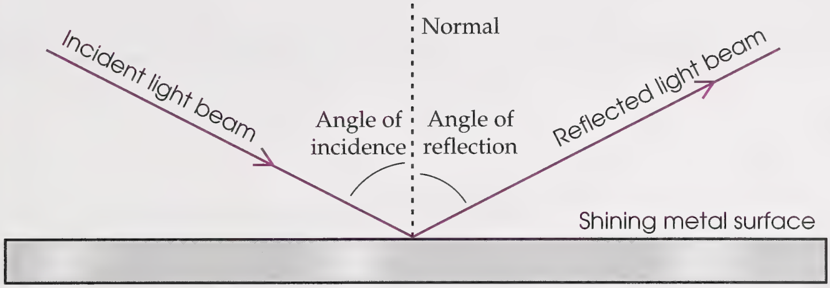
20. When potatoes start to grow roots while in storage, the potatoes begin to spoil. Exposing the potatoes to a cobalt-60 source disrupts the metabolic processes of the cells and prevents the roots from growing.

21. Gamma rays are used to identify certain brain dysfunctions through a process called positron emission tomography. This process uses a radioactive isotope such as oxygen 15$\left({}^{15}_{8}\text{O}\right)$ which emits positrons. When the emitted positron meets an electron the two annihilate each other and release two gamma photons. By detecting and mapping the origin of the gamma rays, the passage of the radioactive isotope through the body can be traced.

22. If the cancer cells are growing rapidly, they are dividing frequently and replicating their DNA. This makes them vulnerable to ionizing radiation. A carefully directed beam of gamma radiation could be used to damage and kill the cancer cells.

Section 2: Activity 3

1.



2. The purpose of this investigation is to investigate the effects of changes in the angle of incidence on the angle of reflection.

3. The following data represents typical results. Most measurement errors are caused by the mirror moving.

Data for the Reflection of Light Investigation																			
Angle of Incidence	0°	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°	90°
Angle of Reflection	0°	5°	10°	14°	19°	24°	28°	33°	38°	43°	47°	52°	56°	62°	65°	70°	76°	82°	too blurred to measure

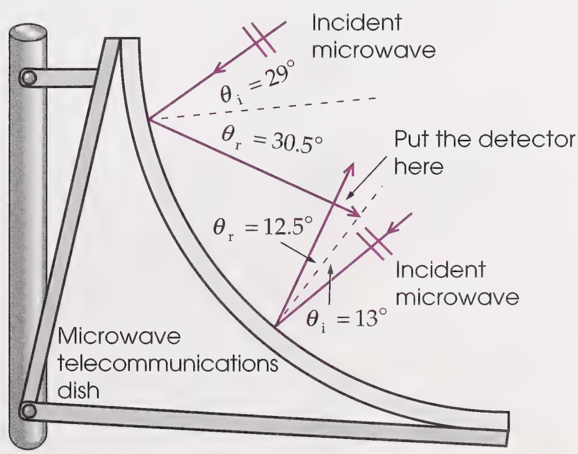
4. **Textbook question 1:** The manipulated variable was the angle of incidence while the responding variable was the angle of reflection.

Textbook question 2: In most cases the angle of reflection is very nearly equal to the angle of incidence.

Textbook question 3: The most common source of error is the movement of the mirror so that it is no longer along the back line. An additional control would be to ensure that the back surface of the mirror (where reflection occurs on the shiny reflecting surface) rather than the front of the mirror was aligned along the back line.

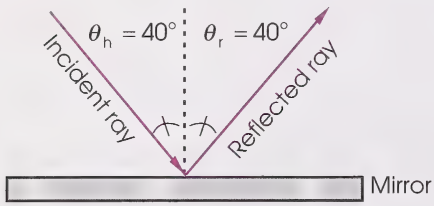
5. The angle of incidence for the AM radio waves was 61° while the angle of reflection was 60°.

6.



7. a. This question is answered on the previous diagram. The detector of microwaves should be placed at the focus of the reflected waves.

   b. If this microwave dish was acting as a transmitter instead of a receiver, then the directions of the arrows on the incident and reflected waves would be reversed. Also a transmitter would be located at the focus instead of a receiver.

8. 

The angle of reflection is 40°.

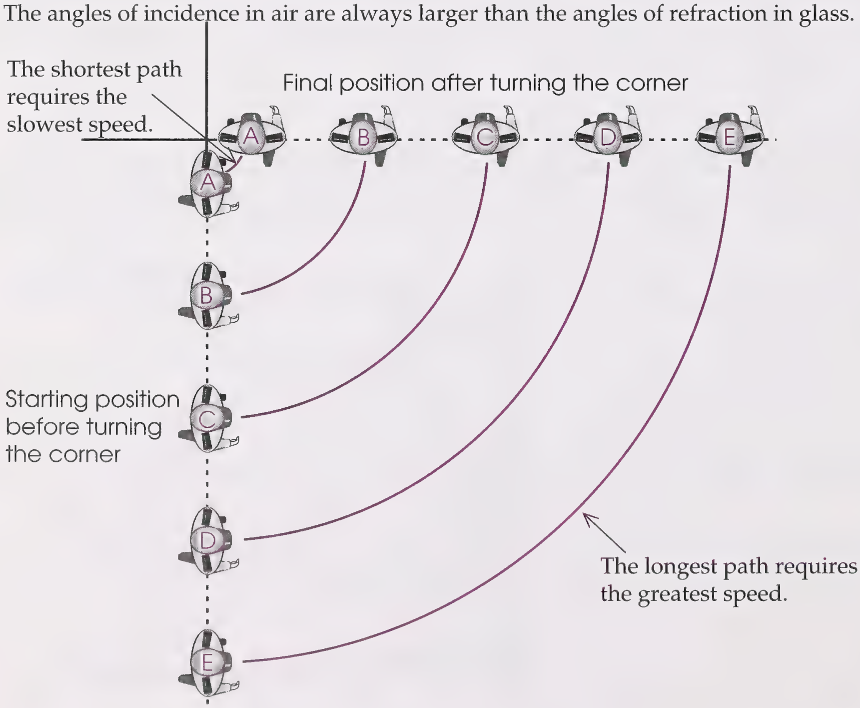
9. The purpose of this investigation is to investigate what happens when light passes from air into glass.

10. The following chart shows typical results.

Angle of Incidence	10°	20°	30°	40°	50°	60°	70°	80°
Angle of Refraction	6°	11°	18.5°	24.5°	28.5°	32.5°	39.5°	This one was unmeasurable.

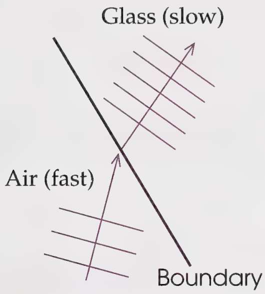
11. The manipulated variable is the angle of incidence while the responding variable is the angle of refraction.

12. The angles of incidence in air are always larger than the angles of refraction in glass.

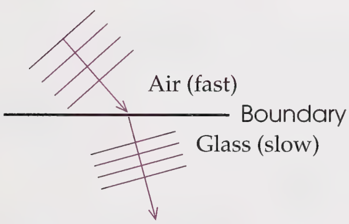
13. 

All members of the marching band have to arrive at the final position at the same time, although the marcher labelled A travels a short distance and the marcher labelled E travels a longer distance. The only way this can happen is for the marchers to have different speeds. The farther the marchers are from the inside of the turn, the faster they have to go. You might tell marcher A to take very short steps while you tell marcher E to take long steps. The marchers in between have to take a size of step that keeps them in line.

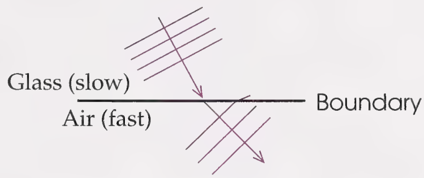
14. a.



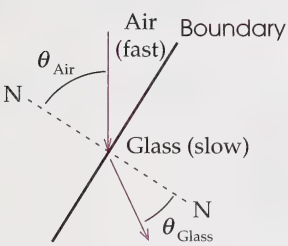
b.



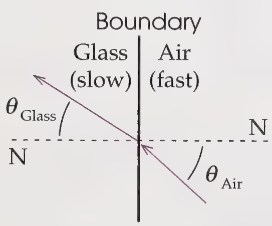
c.



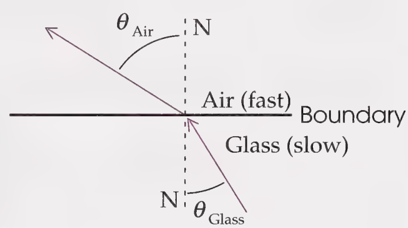
15. a.



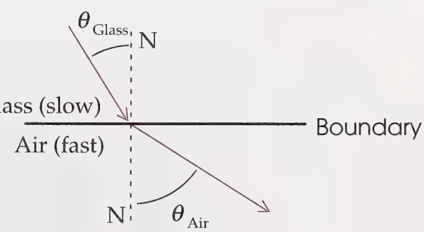
b.



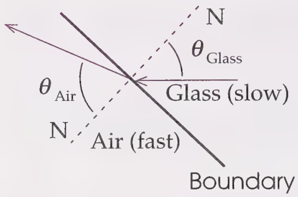
c.



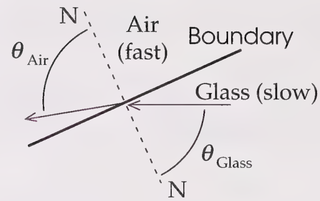
d.



e.



f.



16. The answer to this question is found on the previous diagrams.

17. The medium which passes waves with the greatest speed is also the medium with the greatest angle between the wave ray and the normal. In all cases, the angle on the air side was larger than the angle on the glass side.

18. This angle is called the critical angle.

19. Angles larger than the critical angle result in total internal reflection.

20. The critical angle only occurs when light passes from a slow-moving medium to a faster medium. Because the angle in air is always larger than the angle in glass, there is no limit that occurs in this case.

21. Total internal reflection is used in the design of binoculars and periscopes because total internal reflection is more complete than the reflection that occurs from a plane mirror. Another reason is that the large blocks of glass (prisms) that are used are more rugged than plane mirrors.

22. A fibre optics system is less bulky, less expensive in the long run, and less prone to interference than conventional copper wire cable. Fibre optics systems can also carry hundreds of times the amount of information as conventional systems.

    The main disadvantage with this new technology is that it is expensive to replace the old conventional system with the new one.

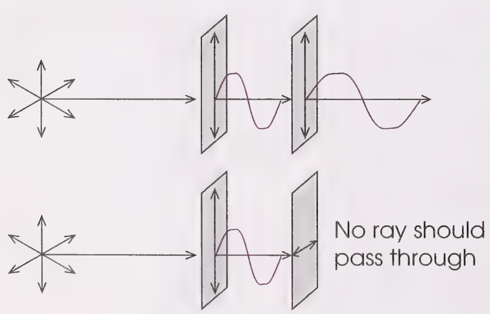
23. A wave is said to be polarized if it vibrates in one plane only.

24. The light transmitted alternated between being brighter and darker.

25. There was no change in the brightness of light.

26. As you rotate one of the filters the transmitted light will get dimmer and then become completely black. Continuing to rotate the filter will cause the transmitted light to become brighter.

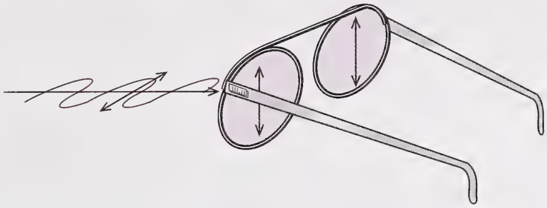
27.



In this case the second filter does the same as the first. The result is that only vertically polarized light is allowed to pass.

In this case the second filter passes only horizontally polarized light. Because the first filter removes all the horizontally polarized light and the second filter removes all the vertically polarized light, there is no light that can pass through both filters.

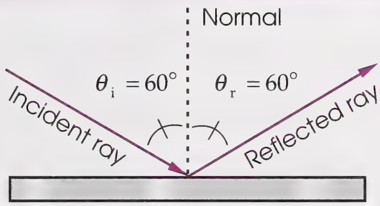
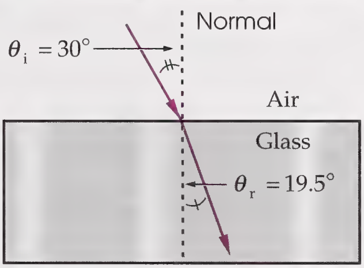
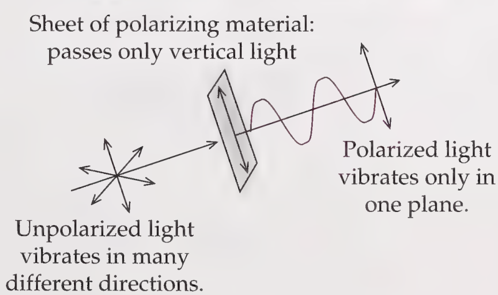
28. To remove light that is horizontally polarized, polarized coating on the sunglasses should be arranged to pass only vertically polarized light.



Section 2: Follow-up Activities

Extra Help

1.

Property	Diagram to Summarize the Property	Applications
Reflection		• mirrors • reflections from still water • satellite and microwave dishes
Refraction		• items with lenses: eye glasses, telescopes, binoculars • mirages
Polarization		• items with a polarized coating to reduce glare: sunglasses, special lenses for cameras

2. The following chart shows representative answers. There are other possible correct responses. Note that the wavelengths have been rounded off in some cases because they were calculated from the stated frequency using $c = f\lambda$.

	Radio Waves	Micro-waves	Infrared Radiation	Visible Light	Ultraviolet Light	X-Rays	Gamma Rays
Range of Wavelengths in Air (m)	3000 to 0.6	0.6 to 3×10^{-4}	3×10^{-4} to 8×10^{-6} m	7×10^{-7} to 4×10^{-7}	4×10^{-7} to 1×10^{-9}	1×10^{-9} to 6×10^{-12}	6×10^{-12} and shorter
Sources	oscillating electrons in a broadcast antenna	charges accelerating in resonant cavities	molecular vibrations	energy transitions within atoms	high energy transitions within atoms	decelerating electrons strike metal surface	unstable nuclei of radioactive materials
Possible Detectors	electrons in a receiving antenna	electrons within molecules	molecules	electrons within atoms	electrons within atoms	electrons within atoms	electrons within atoms
Applications	communi-cations	cooking, radar, satellite communi-cations	identifying heat loss in buildings, search and rescue	lasers (compact discs), vision	test aircraft components, tanning, grow lights	medical diagnosis and procedures	cancer treatment

Note: Wavelength may vary from one information source to another.

Enrichment

1. **Textbook question 1:** The microwaves inside a microwave oven may undergo many reflections. In some cases the waves will combine with each other destructively. These waves will be eliminated resulting in less energy available to heat the food in a particular area. In other areas waves will combine constructively and heat a particular area more than other areas.

2. Helium-neon lasers produce the red beam that is used in supermarket bar-code scanners. Carbon dioxide lasers are used for the precision cutting of materials like ceramic tiles and plastics. Yttrium-aluminum-garnet lasers are used in conjunction with fibre optics systems for very fine laser surgery. Solid state or diode lasers are used in compact disc players.

Section 3: Activity 1

1. There are no right or wrong answers to this question since you are giving an opinion. The following represents typical answers given by students prior to studying this module.

Hazard	Rank
nuclear power	1
motor vehicles	2
cigarette smoking	3
non-nuclear power	5
home appliances	6
food preservatives	4
skiing	7

2. Cigarette smoking is banned from these places because the lifestyle choice of one person should not be able to adversely affect the health of anyone else sharing that space.

Section 3: Activity 2

1. Consider the last statistic that was given.

- time that life is shortened

$$3.5\ \text{a} \times \left[\frac{365.25\ \text{d}}{1\ \text{a}}\right] \times \left[\frac{24\ \text{h}}{1\ \text{d}}\right] \times \left[\frac{60\ \text{min}}{1\ \text{h}}\right] = 1.84 \times 10^{6}\ \text{min}$$

- number of cigarettes smoked

$$[50\ \text{a}] \times \left[\frac{365.25\ \text{d}}{1\ \text{a}}\right] \times \left[\frac{1\ \text{pack}}{1\ \text{d}}\right] \times \left[\frac{20\ \text{cigarettes}}{1\ \text{pack}}\right] = 3.65 \times 10^{5}\ \text{cigarettes}$$

- number of minutes per cigarette

$$\frac{1.84 \times 10^{6}\ \text{min}}{3.65 \times 10^{5}\ \text{cigarettes}} = \frac{5.0\ \text{min}}{\text{cigarette}}$$

2. Consider the fourth statistic that was given.

- number of cigarettes

$$\left[\frac{365.25\ \text{d}}{1\ \text{a}}\right] \times \left[\frac{1\ \text{pack}}{1\ \text{d}}\right] \times \left[\frac{20\ \text{cigarettes}}{1\ \text{pack}}\right] = 7305\ \text{cigarettes}$$

- Determine the mortality rate for one cigarette.

$$\frac{7305\ \text{cigarettes}}{\frac{3600}{1\,000\,000}} = \frac{1\ \text{cigarette}}{\frac{1}{x}}$$

$$(7305\ \cancel{\text{cigarettes}})\frac{1}{x} = (1\ \cancel{\text{cigarette}})\frac{3600}{1\,000\,000}$$

$$\frac{7305}{x} = \frac{3600}{1\,000\,000}$$

$$x = \frac{(7305)(1\,000\,000)}{3600}$$

$$= 2.0 \times 10^{6}$$

The mortality for one cigarette is about 1 in 2.0 million, while the third statistic said 1 in 1.4 million.

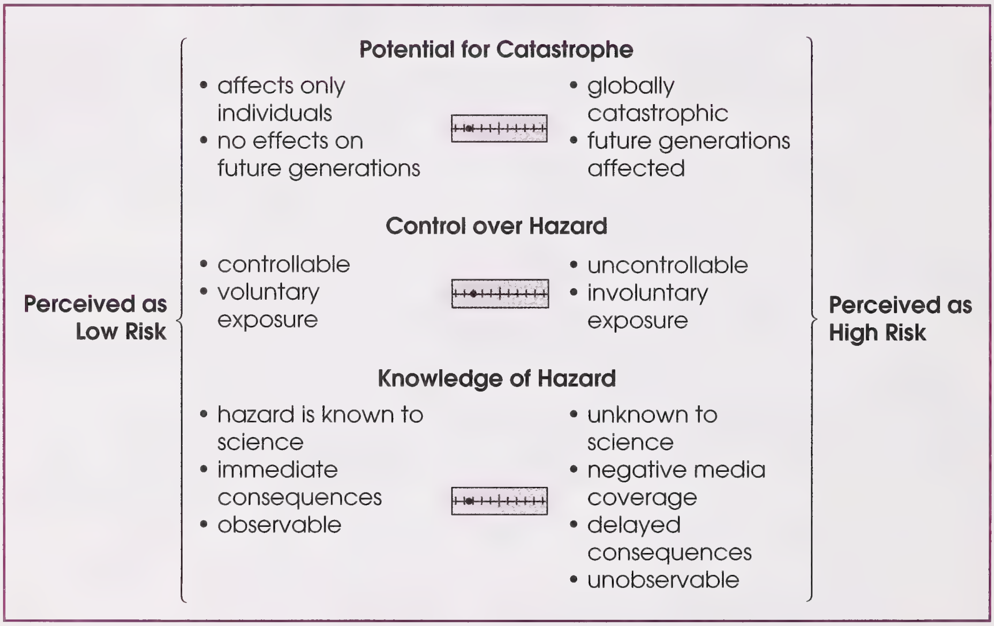
3. The numbers would likely not mean very much because they are so small. More statistics would likely not help since the numbers are so small.

4. Because most people can only understand something as small as 1 in 10 000, a statistic of 1 in 1.4 million would likely be interpreted as being the same as zero probability.

Section 3: Activity 3

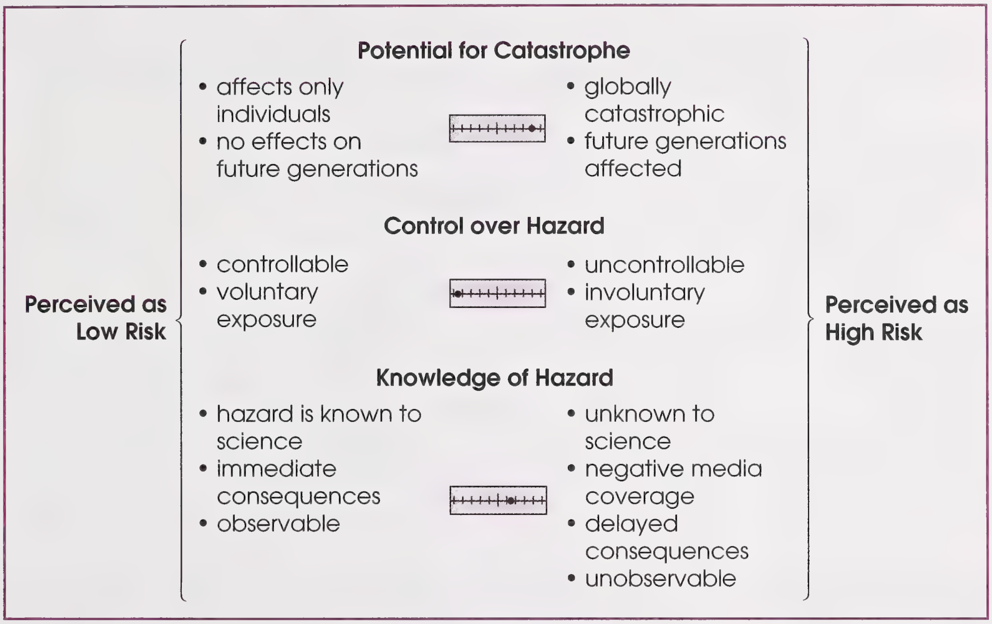
1. Because the three leading causes of death in Canada are motor vehicles, cigarette smoking, and the consumption of alcohol, if a person was able to not smoke, not drink, and to use public transportation, their personal level of risk could be reduced. Although completely avoiding motor vehicles may not be realistic depending upon where you live and what work you do, it is possible to choose not to smoke and not to drink.

2. There are no right or wrong answers to this question. A typical answer is shown. Be sure to check that your explanation is consistent with your rating on the continuum.



Using the continuum and the trends mentioned earlier, most people would probably rate the potential for a catastrophe as being low in this case. Unless you live in a valley below a hydroelectric dam, it is unlikely that you would perceive this as having the potential to kill many people. The same thinking applies to the control over the hazard. Unless you live in a valley below a hydroelectric dam, the hazard should be perceived by most people as being controllable. The non-nuclear generating stations use known, conventional technology, so the perceived risk should be low on this factor as well. Overall, most people would likely perceive non-nuclear electric power as a low risk.

3. As with the previous question, there are no right or wrong answers. A typical answer is shown. Be sure that your explanation is consistent with your rating on the continuum.



The previous response would likely reflect how most citizens would perceive the risk from nuclear power. Many people would describe a nuclear accident as being potentially catastrophic, affecting thousands of people indiscriminately with invisible, mysterious radiation and radioactive fallout. A very high perceived risk would exist in the minds of most people.

Section 3: Activity 4

1. Many possible suggestions could have been mentioned. The following list represents some of these possibilities.

   - Members of the general public may need to learn more about issues so that they can check their perceptions against the risk assessments of the experts.

   - Scientific experts need to explain the nature of risk in clear, understandable language.

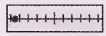
   - The general public and experts need to communicate with each other and become more like partners looking for solutions and less like adversaries trying to prove who's right.

2. As with the previous question, there are no right or wrong answers. A typical answer is shown. Be sure that your explanation is consistent with your rating on the continuum.

Perceived as Low Risk

Potential for Catastrophe

- affects only individuals
- no effects on future generations



- globally catastrophic
- future generations affected

Control over Hazard

- controllable
- voluntary exposure

- uncontrollable
- involuntary exposure

Knowledge of Hazard

- hazard is known to science
- immediate consequences
- observable

- unknown to science
- negative media coverage
- delayed consequences
- unobservable

Perceived as High Risk

This answer reflects the trends mentioned in the previous activity. Most people would likely rate the Potential for Catastrophe and Control Over Hazard categories as being of low risk for suntanning since only individuals who control the amount of tanning through voluntary exposure are affected. The category Knowledge of Hazard would likely be rated by most people as higher risk because of growing negative media coverage and because the delayed consequences are due to an unobservable (invisible) form of radiation.

3. The following factors determine who's most at risk for the more prevalent forms of skins cancer:

- fair skinned people who burn easily and rarely tan
- people who spend a lot of time outdoors involved in recreation or work
- people who have other family members who have developed skin cancer

4. The following factors determine who's most at risk for developing malignant melanoma:

- people who have many moles on their skin, especially if the moles are large and unusual in shape and colour

- people who have had blistering sunburns during childhood or when they were teenagers

- people who have had family members that have developed melanoma

5. The following list summarizes some of the ways of protecting your skin from the sun:

- Stay out of the sun from 11 A.M. to 3 P.M. (daylight saving time).
- Use clothing and a hat to cover up or shade your skin.
- Use a broad spectrum sunscreen with a sun protection factor (SPF) of 15 or higher.

6. The thinning of the ozone layer means that more of the sun's harmful ultraviolet B radiation will reach the surface of Earth. It is this ultraviolet B radiation that is mainly responsible for premature skin aging, sunburns, and skin cancers.

7. Photoaging is caused by the sun; it is a separate process from biological aging. Excessive exposure to the light of the sun causes both the outer layer of the skin (epidermis) and the deepest layers of the skin (dermis) to be damaged. The result is skin that looks loose and leathery giving an older appearance.

8. The damage from the sun to skin is cumulative. When this idea is combined with the fact that a person can have enough exposure to sun by his or her eighteenth birthday to cause cancer, it means that a person can permanently damage his or her skin before reaching adulthood.

9. The UV index monitors the intensity of the UVB radiation that reaches Earth's surface.

10. A reading of 10 on the UV index means that the intensity of UVB radiation is comparable to a typical day in the tropics. This is the highest rating possible as most people will develop a sunburn in less than 15 minutes in these circumstances.

11. The children who were exposed to full spectrum lamps, which included ultraviolet light, reported developing an average of one-third of a cavity per student during the two years of the study compared to one-and-one-half to two cavities per student in the other groups. Other benefits for the U.V. group included slight improvements in overall health, achievement, and attendance.

12. The article says that UVA radiation is not dangerous but recent studies (cited in the previous article) suggest that ultraviolet A radiation contributes to aging, skin wrinkling, and probably to the development of skin cancer.

13. No, these children should not be tanned because the ultraviolet A radiation that was used was only 1% of the acceptable safe limit. Tanned skin is damaged skin that is exposed to more than the safe limit of ultraviolet A radiation as well as ultraviolet B radiation. The study only used small amounts of UVA and did not use any UVB or UVC.

14. The retrofit would cost between $3 million and $4 million while the estimated saving in dental expenses would be about $21 million. The net saving would be $17 million to $18 million over the four-year time period.

15. The study of the children in the schools seems to indicate that low doses of ultraviolet radiation (only 1% of the acceptable safe limit) have benefits that include reducing cavities, saving millions in dental costs, as well as slight improvements in the children's overall health and school achievement. The article by the Canadian Dermatology Association states that excessive exposure of the skin to ultraviolet radiation has a cumulative effect that over a period of years can lead to skin cancer, premature aging of the skin, and wrinkles. In summary, UVA radiation is beneficial in low doses but both UVA and UVB can be quite hazardous when the exposure is strong enough to cause chemical changes in the skin (tanning or burning).

16. The Canadian Cancer Society would say that a suntan only provides the skin with the same protection as a skin block with a rating of SPF 3. This is not nearly enough as the recommended skin blocks have an SPF rating of 15 or higher. (It's worth remembering from the first article that the Canadian Dermatological Association claims that tanned skin is by definition damaged skin.)

17. Although it's true that the lamps in tanning parlours produce UVA light, and it's the UVB light that is the most dangerous, it does not mean that these lamps are safe. The lamps may also emit small amounts of UVB light even though they are designed to emit primarily UVA. The other fact is that evidence is growing that excessive exposure to UVA radiation may cause skin cancer.

    Aside from these concerns, there are all the other potential health problems associated with artificial tanning: wrinkling and premature aging, dilated surface veins, eye damage, and adverse reactions to medications.

    In summary the Canadian Cancer Society regards artificial tanning as a means to permanently damage your skin and adversely affect your health.

18. The lotion may colour your skin but it does not increase the amount of the protective melanin pigment in the skin. Tanned skin only has enough pigment to provide an SPF of 3, and since the coloured lotion does not even provide that, it can not be considered adequate protection against a sunburn.

19. Instead of acting to improve a person's future health and to prevent possible diseases, commercial suntanning likely has the opposite effect.

20. The Canadian Cancer Society and the Canadian Dermatology Association would disagree with the idea that an artificial tan can reduce risks for sensitive people by building up their resistance to the sun. The dermatologists would say that tanned skin has already been damaged by the sun. The Cancer Society and the dermatologists would also argue that a suntan is only equivalent to an SPF rating of 3 or 5 which is inadequate protection against the sun.

21. The experiment to prove or disprove a connection between tanning booths and skin cancer would likely have to be done over a period of 40 to 60 years. This long time would take into consideration the facts that harm to the skin is cumulative (it adds up year after year) and that the actual damage to the skin in the form of skin cancer may not become apparent for many years after the initial exposure. The experiment would also have to include a control group who did not use the tanning beds. Because other things can also cause skin cancer, both the control group and the experimental group would have to be carefully monitored to insure that the other factors were considered when the data was analysed. Controlling these other factors would be very difficult.

    Because tanning booths did not really gain popularity until the mid to late 1980s, sufficient time has not yet elapsed to complete a long-term study.

22. In the article, Han Berkel of the Alberta Cancer Board, states that a suntan is a status symbol in the winter time because it means that you can afford to take a holiday in the tropics. Dr. Caron Grin-Jorgensen of the University of Connecticut believes that a suntan is a fashion statement that can be traced back to a trend started by Coco Chanel in the 1920s.

23. Most dictionaries define lifestyle to be a way of life that reflects the attitudes and values of a person or their culture. It follows from this definition that a healthy lifestyle would be one that demonstrated good health as an important value to that person. For example, a person leading a healthy lifestyle would likely exercise regularly, would eat sensibly, and would refrain from cigarette smoking and alcohol abuse.

24. There are many possible answers to this question. One example of a healthy fashion trend would be the activity of joining a fitness club and regularly working out. Other examples could include jogging or walking, eating fibre, and so on.

25. At least 50% of the population have the misconceptions that cancers are due to the following causes:

- Everything causes cancer.
- There is very little a person can do to avoid cancer.
- Cancer is caused by a blow or bruise to the body.
- Food additives are a major cause of cancer.
- All forms of pollution cause cancer.

26. Recent research indicates that 50% to 60% of cancers are caused by lifestyle choices. This means that people are choosing to do things and to eat things that can cause cancers. If people made different choices, then the incidence of cancer could be greatly reduced.

27. The following answers represent some of the possible approaches to this question. It should be noted that it is not the particular opinion (A or B) that matters, but rather how the opinion is supported according to the criteria stated in the question. You should read both of the answers provided as it will help you to see the problem from more than one perspective.

- Opinion A

  "People should not try to get a tan. It's almost criminal. It's wrong. It's just asking for trouble."[1] These are the words of Orest Talpash, an Edmonton dermatologist. In this essay I shall outline why I think that people who ask for trouble by excessive suntanning should be responsible for the outcomes of their behaviour by helping to pay for any extra care and treatment that they may eventually require.

  The motivation for excessive suntanning has been described as a fashion statement and/or a status symbol. Almost all other things that fall in the fashion/status category, such as driving a sports car or wearing authentic jewellery, are very expensive. These things are not subsidized by government tax breaks because they are not essential. Why should suntanning be any different? Why should an already burdened health care system pay for self-inflicted ailments caused by tanning? If people want a dark tan they can pay for it by picking up their own health care costs if they eventually become ill.

  The mayor of Edmonton, Jan Reimer, was right when she compared commercial suntanning to selling tobacco, because in both cases the service harms the health of the user. If tobacco products have warnings printed on the packs and are heavily taxed to discourage people from smoking, then perhaps commercial tanning facilities should have a warning posted at the entrance and the tanning fees should be heavily taxed. The collected taxes could help fund future skin cancer treatments.

  The alternative opinion maintains that education should be an adequate way to solve the problem. This is not an effective approach to take. The main difficulty with this approach is rooted in the risk perception continuum for suntanning. For most people the perceived risk is low while the immediate gratification of status and fashionability is strong enough to overshadow any potentially hazardous long term consequences. This is reflected in the brochure supplied by the Canadian Dermatology Association: "Dermatologists have been warning people to protect themselves from the sun for many years. Skin cancer rates have been steadily increasing despite these warnings."[2]

  Clearly, using only education does not work. Behaviour will only change when the consequences are made more immediate and are closely tied to people's wallets.

---

[1] *The Edmonton Journal* for the article "Save Your Hide," by Bill Sass from, May 28, 1992, page C9. Reprinted by permission of *The Edmonton Journal*.
[2] *Sun Facts*, a brochure published by the Canadian Dermatological Association.

- Opinion B

According to the Canadian Cancer Society 50% to 60% of cancers are linked with lifestyle choices—the things we do and what we eat. In this essay I shall outline why it's better to convince people to make healthy choices through educational programs. To use the phrase of Dr. James Howell, Edmonton's medical officer of health, "the principles of preventative health" clearly speak to the concerns raised by excessive tanning.

The educational approach could begin by going right to the heart of the problem by attacking the two things that motivate people to get a suntan: fashion and status. If prominent models and film stars were convinced to have untanned skin, then the reverse fashion trend could be generated. It would be in the interest of their own careers to do this because they could look younger for many more years if they avoided excessive tanning. Untanned skin could also become a status symbol just as it was in previous centuries, as evidenced in the paintings of artists like Rubens.

The educational approach requires time. Even though dermatologists have been warning people for some time and media coverage has helped in recent years, it will take a long time to change attitudes and even longer to experience the benefits of a healthier population. The time factor has to do with the fact that exposure to the sun is cumulative and that cancers often do not appear until many years after the initial exposure. The increase in skin cancers now is due to overexposure to the sun in previous decades when very little educational material was available to the general public. Had educational programs been in place in the 1950s through to the 1980s, then the incidence of skin cancer might be considerably less than it is now.

The alternative approach of extra health care payments is unworkable. If everyone who had a tan got it from a tanning parlour, then there might be a chance of collecting a special tax and monitoring exactly how often the patrons use the service. However, many people tan in their backyards or at the beach where monitoring would be very difficult. The other problem with this scheme is that much of the skin-damaging exposure to the sun occurs by the time people are 18 years old. Can people be held responsible for their behaviour as children? What responsibility would negligent parents have in this system? Clearly this strategy has its problems.

Since a lifestyle choice reflects the values and attitudes of an individual or their culture, it will take time for the educational approach to work because attitudes take a long time to change. However, the investment is worth it because of the improved health of so many people.

Section 3: Follow-up Activities

Extra Help

1.

COMPARING RISK ASSESSMENT TO RISK PERCEPTION		
	Risk Assessment	**Risk Perception**
Who does it?	experts	general public

What strategies are used?	Probability and statistics are used to carefully analyse available data. In many steps of the procedures, estimates have to be made, which make risk assessment an inexact science.	Studies have demonstrated that lay people tend to employ three basic criteria when determining risks: • potential for catastrophe • degree of control over the hazard • knowledge of the hazard
What is the outcome of this process?	a probability with an associated uncertainty	an opinion in the mind of the observer

2. Experts and the general public employ very different strategies, so the outcomes are often different. While the expert may focus only on things that can be measured or counted, the general public has a much broader notion of risk that encompasses considerations that may be overlooked by the expert.

Enrichment

1. a. The internal report produced by Batco revealed that there was a definite cause and effect relationship between cigarette smoking and cancer.

   b. The tobacco industry was forced to deny that cigarettes caused cancer because no industry could accept that its product was toxic because it would mean loss of jobs and profits. However this position created the dilemma that if the industry eventually developed a safer cigarette then they would have to admit that their original cigarettes posed a health risk that precipitated the development of a safe cigarette.

   c. The difficulties in producing a safe cigarette were two-fold. The first problem was that as they worked to design a filter to remove one carcinogenic substance, the scientific community would find another substance that was equally, if not more, dangerous than the first. In the end, none of the filters proved to be very effective. The second problem was that since a cigarette was thought of by the industry as a nicotine delivery device, then it was important for the nicotine to be delivered in a reasonable dose with enough smoke and flavour to satisfy the consumer. This proved to be a very difficult problem to solve.

   d. The tobacco industry provides employment and benefits to thousands of people. It is difficult to have growers suddenly change to another crop or to have the tobacco packaging industry change to another product.

2. a. Two sets of values are needed to describe the two distinct components of the electromagnetic radiation. One value measures the strength of the electric field, the other value measures the strength of the magnetic field.

   b. The transmission line would expose a user to stronger electric fields while the electric blanket would expose the user to stronger magnetic fields.

   c. It is difficult to establish the link between ELF and health problems of people because it is so difficult, if not impossible, to control all the variables. For example, if the incidence of childhood leukemia is higher in a neighbourhood that borders a transmission corridor, then how can the researchers be sure that it was the ELF that caused the higher leukemia rates and not some other factor such as contaminated drinking water.

Articles

Sun Facts[1]

Be Sun-Safe...Not Sorry. This year, more than 47,000 Canadians will discover they have skin cancer. Most have developed this common disease because they spent too long in the sun over many years.

In fact, we are all spending more and more time in the sun as we place greater value on our leisure hours. At the same time, the incidence of skin cancer in Canada is rising. Anyone born today faces a one-in-seven chance of getting this disease during their lifetime.

The good news is that skin cancer is almost totally preventable. Simple precautions to protect your skin from the sun will help prevent the development of skin cancer. You can save your skin!

Who's at Risk?

The reaction of your skin to the sun, and the amount of time you spend in the sun, will tell you a lot about your risk of developing skin cancer.

If you have one or more of these risk factors, you may face a higher risk of developing skin cancer.

- If you have fair skin and you burn easily and rarely tan. The sun's ultraviolet rays damage the skin. In response to this injury, the skin produces a melanin, a pigment or darker colour, which filters out some of this harmful radiation. Fair-skinned people often can't produce enough melanin to provide protection for their skin and so they are open to increased damage from these rays. They need to take special care when out in the sun.

- If you spend a lot of time outdoors either through your job or through recreation. People employed in the construction industry, outdoor municipal or government workers, lifeguards, farmers and fishermen have a greater chance of developing skin cancer. Keen sailors and outdoor sports enthusiasts also fall into this group. These people are constantly under the sun's dangerous rays. While a tan fades at the end of summer, sun-induced damage to the skin just keeps on adding up, year after year. Research has shown that the more our skin is exposed to the sun, the more likely we are to develop skin cancer.

- If you have a personal or family history of skin cancer you have an increased risk of developing the disease.

These are the risk factors for the more common types of skin cancer. These more prevalent forms of the disease can lead to pain and disfigurement if left untreated but rarely lead to death.

However, there is a less common, but rapidly-increasing kind of skin cancer, malignant melanoma, which is responsible for the majority of deaths from this disease. This year, 3,100 Canadians will develop melanoma and 540 will die from it.

- You may face a higher risk for developing melanoma if you have many moles on your skin and if some of these moles are large (bigger than 5 mm in diameter or the top of a pencil eraser), or unusual in colour (multiple colours) or surface features. This is because melanomas have been known to develop in or around existing moles. They often also appear as a new coloured spot on the skin.

- Research suggests that several blistering sunburns during your childhood or teenage years may also increase your risk of getting melanoma.

- A personal or family history of melanoma is another risk factor for this most dangerous type of skin cancer.

Sun Facts (And Fiction!)
Quick Tips

Protect your skin from the sun every day from Spring right through to early Fall and during winter if you're involved in winter sports. If you have suffered from skin cancer, protect your skin year-round.

Never rely on your skin to tell you when to get out

[1] The Canadian Dermatology Association for the articles in *Sun Facts*.

of the sun. By the time your skin hurts, it has been severely damaged by the sun.

The Best Way

The best way to protect your skin from the sun is to stay out of the sun from 11 am to 3 pm (daylight saving time). During this period the sun's harmful ultraviolet B radiation, the prime cause of sunburn, skin aging and skin cancer, is strongest. Venture out either earlier or later in the day when the intensity of these rays is only about one quarter that of noon.

Other Ways

If you have to be out in the sun during these times, use clothing and a hat as a means of protecting your skin. A long-sleeved shirt and pants offer excellent protection.

Clothing acts as a physical block to stop the sun's rays from getting through to your skin. Closely-knit fabrics work best. As a rule of thumb, any garment that you can see through also lets ultraviolet rays through.

When a fabric is wet it loses some of its ability to block out solar rays. The material becomes more transparent and allows light to penetrate through to the skin.

Bear in mind that synthetic fabrics offer better protection than cotton.

Choose a sun hat carefully. Straw hats often let light through. Baseball caps don't shield the back of the neck or the ears—areas where skin cancers often appear.

Wide-brimmed (3 inches wide on all sides) or legionnaire-style hats are your best buys.

Which Sunscreen?

Dermatologists recommend using a broad-spectrum, SPF 15 sunscreen on all exposed areas of the skin. An explanation of these standards follows, but first some important points about buying and using sunscreens:

- Keep in mind that no sunscreen offers complete protection from the sun.

- Remember sunscreens have to be applied at least 15 to 30 minutes before you go out to allow the active ingredients to soak into the skin. Sunscreens should be reapplied frequently (every two hours) and liberally especially after swimming or sweating.

- Don't forget to use sunscreen on the ears, nose, neck and bald spots since these are the areas where skin cancers most often occur. Skin cancers also appear on the lips, so use an SPF 15 sunscreen lip balm too and reapply it.

- If the first sunscreen you try isn't suitable for your skin, experiment with another product—chances are that you will find one that suits your skin.

- When buying sunscreens, be on the safe side and look for products that have been evaluated by the Canadian Dermatology Association and bear the association's logo.

What is an SPF?

The SPF or sun protection factor of a sunscreen refers to the protection offered against the sun's dangerous ultraviolet B rays, known to cause both sunburn and skin cancer.

The SPF of a product relates to the time it would take for your skin to burn without any protection compared to the length of time you could remain outside without burning when wearing a sunscreen. In theory, you could stay out in the sun fifteen times longer without burning your skin if you used an SPF 15 sunscreen.

In practice, people often don't use enough of the sunscreen or don't reapply it and its effectiveness is therefore limited. Bearing in mind how people use sunscreens and the product's ability to screen out ultraviolet rays, sunscreens with an SPF of 15 are recommended.

Sunscreens are not intended to increase your sun exposure time but to increase your protection during unavoidable sun exposure.

Broad-spectrum sunscreens

Most sunscreens are now labelled 'broad spectrum' and that means they offer protection against the sun's ultraviolet B and part of the ultraviolet A rays. Recent research suggests that ultraviolet A rays contribute to skin aging, wrinkling and probably the development of skin cancer.

Sunburnt on a Cloudy Day?

Most of the sun's damaging ultraviolet rays can penetrate light cloud cover, haze and fog. These rays are invisible and they don't feel hot so we're often fooled by clouds and our skin suffers.

Skiers And Surfers Beware

We can get an extra dose of ultraviolet radiation because it reflects off many surfaces around us. Up to 50 percent of the rays can bounce back at you off snow, concrete and sand.

Heightening the Risk

Skiers, tobogganers, hang-gliders and mountaineers are exposed to more ultraviolet rays than someone at sea level. The higher up we are, the less atmosphere there is around to absorb these rays.

Does a Tan Protect My Skin From The Sun?

This is a question that sends shivers down the spine of any dermatologist. A tanned skin has already been damaged by the sun.

A tan is your skin's response to the injury that ultraviolet radiation has caused. Your skin is producing melanin to help screen out these rays. However, an average tan is equivalent to an SPF of about 3 to 5 which is inadequate against the powerful rays of the sun.

Even people who have naturally darker skin types, such as those of Hispanic origin who tan easily and never burn, can develop skin cancer if they spend too long in the sun without protecting their skin.

Don't Be a Wrinklie

So all the scary skin cancer statistics have had no effect on you. You're going out to get a tan this summer because you feel it makes you look more attractive and healthy.

Well stop right there!

The sun actually speeds up the aging of your skin. To put it bluntly—that means more wrinkles, sagging skin and unsightly blotches at an earlier time in your life.

This accelerated skin aging, known as 'photoaging' is a separate process from normal biological aging. Photoaging is caused by the sun. Haven't you ever wondered why the sun-exposed areas of the body, like the face and the backs of the hands, start to look older earlier?

Photoaging can start showing up in your early twenties. The eyelids, where your skin is only 1 millimetre thick, are especially prone to showing the effects of aging sooner.

What happens to our skin when it is exposed to solar radiation is a destructive process.

The outermost layer of our skin, the epidermis, begins to dry out with more and more sun exposure.

When harmed by the sun, the melanin-producing cells go on to manufacture discoloured patches called "age" or "liver" spots.

In the dermis, the deepest layer of our skin, a support structure of collagen and elastin fibres, responsible for the skin's tone and resilience, is damaged, leading to wrinkling. Blood vessels are harmed and blood flow is limited, giving the skin a dull and sometimes sallow look.

Sweat and oil glands do not function effectively and cell regeneration slows down. The lack of moisture and oil causes dryness.

You can pick out seasoned sunworshippers by their leathery, waxen skin which sometimes hangs in folds. They probably look at least ten years older than they are.

For your good looks alone—protect your skin from the sun!

Less Ozone, More Danger

Why are we making such a fuss about the thinning of the ozone layer?

After all, we're talking about a gas spread so thinly in the stratosphere that if all the ozone was collected at the earth's surface it would form a layer only 3 millimetres thick!

Yet this delicate veil of gas prevents much of the sun's powerful ultraviolet B radiation from reaching the earth.

At the moment between 10 and 30 percent of ultraviolet B radiation (UVB) gets through the ozone layer. Even this small amount of UVB brings about severe, destructive effects on our skin ranging from sunburn to wrinkles and skin cancer. In Canada this year there will be 47,000 new cases of the more common types of skin cancer.

Some man-made chemicals such as CFCs or chlorofluorocarbons, used in aerosol propellants, refrigerants, solvents and foam-blowing agents, act to thin the ozone layer allowing more UVB to filter through to us.

During the past decade, the amount of ozone over Canada has been depleted by an average of approximately five percent year-round, which is estimated to have resulted in a 10 percent increase in the amount of UVB reaching us.

And more UVB means more cases of skin cancer. United Nations projections are that a five percent loss of ozone will mean a 13 percent increase in the number of cases of skin cancer—or thousands of extra cases a year.

Given that it takes between ten and twenty years for skin cancer to develop, we are expecting to see these additional cases of the disease early in the next century.

However, something we might notice as early as this summer, is that we may get sunburnt within a shorter period of time.

In the long term, more UVB might also make us look older before our time (UVB is the leading cause of premature skin aging) and we may get skin cancers at an earlier age.

These grim prospects look even worse in the light of a prediction by the United Nations that we are going to see a further five percent depletion of the ozone layer during the 1990s.

Dermatologists have been warning people to protect themselves from the sun for many years. Skin cancer rates have been steadily increasing despite these warnings. The depletion of the ozone layer simply adds to the problem.

It's never been more important for families to be sun-safe.

Babies, Children and Sun-Sense

If you can protect your children from the sun you may significantly lessen their lifetime risk of developing skin cancer.

This is because sun-induced damage to our skin is cumulative. While our tan fades away, the harm done to the skin just adds up, year after year. By the time we reach adulthood, many of us have soaked up enough sun to develop skin cancer.

As well, most of us don't realize just how long children are out in the sun. Much of our lifetime sun exposure has occurred by the time we are 18 years old. Consider the summer holidays—while adults might be in offices or indoors at home, children are outside in the sun for hours on end.

So how can we protect our children from the sun's dangerous rays?

- Keep babies under one year old out of direct sunlight. This will not only protect their skin against sun damage but will also prevent dehydration or sunstroke. Keep them protected in a covered stroller, under an umbrella or in the shade.

- Do not use sunscreen on babies under 6 months old. A baby is likely to absorb more of the product through its skin than an older child would.

- Keep toddlers and older children out of the sun during the peak hours of 11 am to 3 pm (daylight saving time) when the sun's powerful ultraviolet B radiation is strongest. Try to get their preschool or school schedules changed so that they are not outside during these hours.

- Don't book their sports lessons or practice during this time—try to schedule their time outdoors before 11 am or after 3 pm.

- Look at providing more shade in the form of trees and shade structures. Have you planned your children's play area in a shady spot? If they have to be out in the midday sun at recess, are there trees in their playground or can shade structures be put up?

- Reinforce basic sun sense everywhere they go. During the summer months, send them to school or preschool with a wide-brimmed sunhat or a legionnaire-style cap, protective clothing (see below) and an SPF 15 sunscreen.

- Don't forget that clothing, especially that made of closely-woven materials, offers natural protection from the sun. As a rule of thumb, if sunlight can get through the material, so can ultraviolet rays. A long-sleeved shirt and long pants offer the best protection against the sun.

- Children over the age of six months old can wear a sunscreen. However, sunscreens should not be thought of as adequate protection on their own and should be used with other forms of natural protection like clothing, hats and shade.

- Dermatologists recommend a broad-spectrum, SPF 15 sunscreen that screens out most of both the ultraviolet B (UVB) and ultraviolet A (UVA) rays of the sun. Look for the Canadian Dermatology Association logo on sunscreen products to be on the safe side.

- Whenever possible, apply the sunscreen at least 15 – 30 minutes before exposure. The extra time allows the active ingredients to sink into the skin. Reapply frequently and liberally, particularly after swimming or sweating. To avoid burning the tops of thighs and chest areas, apply sunscreen to a child's body before putting

on a bathing suit. Pay special attention to the back of the knees and the top of the foot.

- Apply carefully around the eyes, avoiding the upper and lower eyelids. Children tend to rub their eyes and some sunscreen products can be irritating.

- Use a lip balm for vulnerable areas such as the lips, nose and ears.

- Choose a water-resistant or waterproof product if your child is playing in water or perspiring heavily.

- Be especially careful if your children are fair-skinned and have blonde or red hair. These children are most at risk for developing skin cancer as they burn easily.

- Watch out for reflected light since up to 50 percent of the sun's harmful ultraviolet B radiation bounces back at you from sand, snow and concrete. Little skiers need sun protection.

- Children can get sunburnt even on a cloudy day. Up to 80 percent of the sun's rays can penetrate light clouds, mist and fog. Protect your children from the sun year-round.

- If your children are on medication, check with your doctor before allowing them out in the sun. Adverse reaction to sunlight characterized by a rash, redness or swelling can be a side effect of various medications.

- Never use baby oil as a sunscreen. The oil will intensify the effect of the sun and cause children to burn faster.

Ozone Watch rates those harmful rays[1]

Susan Bourette
Journal Staff Writer, Edmonton

Summer and a golden tan—they go together like Laurel and Hardy, baseball and hot dogs.

Right?

Well, a new daily weather service which monitors the intensity of ultraviolet-B rays will most likely remind Edmonton residents that tanning and summer are about as suited as pickles and ice cream.

The Ozone Watch program started Wednesday providing daily, local ratings of the dangerous UV-B rays which can cause sunburns and skin cancer.

"We are trying to provide a service which we think people can use to adequately protect themselves from the sun," said Tim Goos, head of science services at Atmospheric Services an arm of Environment Canada.

The program, a joint initiative of Environment Canada and Health and Welfare Canada, is part of the $25-million Green Plan. It will measure UV-B rays on a scale from 0 to 10, with a 10 rating being comparable to a typical day in the tropics.

A rating of below 4 on the scale is considered low and gives people more than one hour before they would start to get a sunburn, between 4 and 6.9 the time is about 30 minutes, and between 7 and 8.9 it's 20 minutes. More than 9 is considered extreme with a sunburn time of less than 15 minutes.

Health and Welfare Canada figures suggest that Edmonton's typical mid-summer UV-B level is 7, Toronto's 8 and Yellowknife's 6.

UV-B rays are the most harmful because they can cause skin cancer and temporary loss of vision.

The initiative follows concerns raised by scientists' warnings about a thinning of the ozone layer.

Goos said the Edmonton area has shown a six to eight percent decrease in the ozone this spring.

While people often think about protecting themselves while they're vacationing in Hawaii, many don't at home, he said.

Edmonton residents can get the UV-B rating by contacting the Alberta Weather Centre at 468-4940. The rating will be provided on a recorded message between 5 a.m. and 4 p.m. and will soon be included on *The Journal* weather page.

[1] *The Edmonton Journal* for the article "Ozone Watch rates those harmful rays," by Susan Bourette from May 28, 1992, page B1. Reprinted by permission of *The Edmonton Journal*.

Gov't study links ultraviolet light with fewer cavities, better health[1]

Marta Gold
Journal Staff Writer, Edmonton

Alberta primary school children in classrooms with full-spectrum lamps including ultraviolet light have fewer cavities and better general health, says a provincial government study.

And the Alberta Education official who headed the study says he'll recommend that the government switch classroom lighting across the province, at a potential cost of millions of dollars.

The grades 4, 5 and 6 students in five central and southern Alberta schools in the 1987–1989 study were exposed to three types of light: high-pressure sodium vapour lights, full-spectrum lamps without ultraviolet light and full-spectrum lamps with ultraviolet light.

The sodium vapour lights give off an orange colour while the full-spectrum lamp with ultraviolet most closely mimics natural light.

"In the presence of ultraviolet, the kids developed fewer dental problems," Dr. Warren Hathaway, assistant director of research and education technology for Alberta Education, said Thursday.

That was the clearest and most surprising finding of the study, he said. Modest improvements in overall health, including more body weight gain and a slight improvement in achievement and attendance, were also noted among the children exposed to ultraviolet light.

"The value of the avoided dental costs would add up to $21 million in that same period of time."

—Dr. Warren Hathaway,
Alberta Education

The study echoes the findings of a similar Alberta examination between 1984 and 1985, which focused only on dental health, said Hathaway.

"But we really weren't convinced with the first study. It's still awfully hard to build a government policy on one study."

The two Alberta studies are the only ones in North America, and possibly in the world, to focus on the effects of light on human subjects, he added. Other studies have looked at the effects upon laboratory animals.

Children exposed to full-spectrum lamps including ultraviolet light developed an average of one-third of a cavity each during the two-year period. The other children developed an average of between $1\frac{1}{2}$ and two cavities each in two years, Hathaway said.

In order to expose the children to ultraviolet light, which was clearly the beneficial factor in the full-spectrum lighting, both the bulbs and fixtures had to be changed, said Hathaway.

A polished aluminum reflector was put in with the bulb and the plastic lens was replaced to allow the ultraviolet light through.

Ultraviolet light flows in three bands, known as A, B and C. The C-band light is the one known as dangerous, while the A-band is not. The amount of A-band ultraviolet light emitted by the school lamps was about one percent of the acceptable safe limit.

Hathaway said the cost of switching the lights in up to 5,000 Grade 4, 5 and 6 classrooms in the province could be between $3 million and $4 million. Once installed, the lights will last four years.

"The value of the avoided dental costs would add up to $21 million in that same period of time," he said.

But the switch will be hard to make because of the cost, Hathaway added.

"Even though there's this marvellous benefit, Alberta Education doesn't get it. It goes into the pockets of the parents who don't have to pay dental costs. So that's the conundrum."

Hathaway said the study team is still writing its report and should be presenting the results to the government by Christmas time.

---

[1] *The Edmonton Journal* for the article "Gov't study links ultraviolet light with fewer cavities, better health," by Marta Gold from November 1, 1991, page A7. Reprinted by permission of *The Edmonton Journal*.

Artificial Sun[1]

Many people think that artificial tanning methods are safer than the sun. Not so. Getting a tan indoors can damage your skin. Permanently. If you want to find out more, read on.

In spite of ads to the contrary, sun tanning beds, booths and lamps do damage skin—eventually. Over time, skin exposed to ultraviolet (UV) rays, regardless of the source, feels leathery and begins to look older, dried out and wrinkled. Moreover, repeated exposure to ultraviolet light rays is known to cause the commonest types of skin cancer.

Tanning parlours promote "safe tanning without burning" because they use lamps that emit mostly ultraviolet (UVA) rays. UVA rays bronze skin without necessarily burning it but may still cause skin damage. These lamps may also emit small amounts of ultraviolet B (UVB) rays. UVB rays can more readily burn your skin, therefore, the more you use these lamps, the more you expose your body to harmful ultraviolet rays.

Over time painless artificial tanning may cause as many irreversible skin changes as painful sunburns. By exposing yourself continually to ultraviolet rays you increase your risk of:

- Skin cancer
- Brown blotchy discolouration
- Wrinkling and premature aging
- Dilated surface veins
- Damage to the eye's cornea and lens (cataracts)
- Adverse reactions from medications

Avoiding artificial tanning lamps makes good skin sense. However, if you feel you must have a "year round" tan, remember these facts:

- Artificial tans protect skin from natural sunlight only minimally (SPF 3); if you burn easily in the sun, these lamps are dangerous because they give you a false sense of security.

- Exposure to the sun triggers cold sores in some people; artificial tanning lamps can also do this.

- Some medications such as certain sedatives, antihistamines, anti-diabetic agents and antibiotics make some people's skin sensitive to UV light. If you're on any of these drugs, you may be increasing your risk of developing a skin allergy (photo-allergy) to the sun's rays or those of a tanning lamp. You should consult your doctor about the possibility of developing a sun allergy if you are on certain medications.

Protect your skin by:

- Beginning with short exposures.

- Never staying under a lamp longer than the time recommended for your skin type.

- Always wearing protective goggles with lenses that block out ultraviolet light.

Remember, sunlamps or tanning lamps have the potential to damage your skin.[1]

[1] "Artificial Sun" from the pamphlet *Skin Sense: Indoor tanning is no safer than the Sun* (#211823) ©1989 Canadian Cancer Society. Reprinted with permission.

Shaking Up Indoor Tanning Myths[1]

Tanning Parlour tans protect the skin before going into the sun.
False: Although the skin bronzes, it has only developed a small amount of pigment (SPF 3) needed to protect it from a sunburn out-of-doors.

People with light skin can tan safely at a tanning parlour.
False: People with fair complexions can suffer as much skin damage as they would in the sun. Since these people have less protective melanin pigment, they often burn instead of tan.

Sunscreens don't have to be used in tanning parlours.
False: Skin, exposed to ultraviolet rays, will still be damaged whether these rays are emitted from tanning lamps or the sun. Therefore, the skin must be protected.

Tanning parlour lamps do not cause skin cancer.
False: There is increasing evidence that UVA may cause skin cancer particularly the lethal malignant melanoma as well as aging the skin.

Tanning pills and lotions are the safe way to a bronze skin.
False: Pills and lotions may colour the skin, but they don't significantly reduce the risk of sunburn.

People will be well-protected from burning if they use tanning pills and lotions before they start sunbathing.
False: Pills and lotions may colour the skin, but they don't increase the pigments that protect you from sunburns.

City's proposal to get rid of suntan beds burns leasing company[2]

Scott McKeen
Journal Staff Writer, Edmonton

The only one who got badly burned by the suntan beds at Edmonton swimming pools was the company leasing them to the city, its president charged Monday.

Alan Christiansen says health concerns surrounding commercial tanning have been "blown right out of proportion."

He said he will lose a considerable amount of the $100,000 he invested in suntan beds if council shuts them down for good.

He's angry that the Parks and Recreation Department is recommending the city get out of the suntanning business, based on a letter of warning from the city's medical officer of health, Dr. James Howell.

Howell writes that the Edmonton Board of Health cannot endorse commercial tanning.

"No amount of precautions we recommend can obviate the risk of radiation exposure," said Howell adding that commercial suntanning goes "against the principles of preventive health."

Christiansen said the suntan beds, if used properly, pose no greater risk than natural sunbathing. And if anything, they reduce the risk for sensitive people of exposure to harmful sun's rays by building up resistance, he said.

Christiansen's company, Conalco Suntan, and Health Equipment Leasing has leased tanning beds to the city since 1987. He also built the suntan rooms and helped train staff to ensure the beds were being used safely.

---

[1] "Shaking Up Indoor Tanning Myths" from the pamphlet *Skin Sense: Indoor tanning is no safer than the Sun* (#211823), ©1989 Canadian Cancer Society. Reprinted with permission.
[2] *The Edmonton Journal* for the article "City's proposal to get rid of suntan beds burns leasing company," by Scott McKeen from December 5, 1990, page B6. Reprinted by permission of *The Edmonton Journal*.

Mayor fails to block the 'sun'[1]

Tanning booths to remain at city-owned pools
Mike Sadava
Journal Staff Writer, Edmonton

Mayor Jan Reimer failed in her attempt to be a sunscreen Wednesday.

City council's executive committee overrode her objections to the possible hazards of tanning and decided the city should allow tanning booths in city-owned pools.

"It's like selling tobacco," said Reimer, who argued the city shouldn't get into services that could harm the health of users.

"The city licenses all sorts of things like massage parlours that we may not agree with," Reimer said. "But that doesn't mean we get into the business ourselves."

The incidence of skin cancer is rising to alarming proportions, Reimer said, citing the melanoma found recently in Quebec Premier Robert Bourassa.

John O'Laney, director of environmental health for the city, said he is concerned there could be an association between tanning booths and skin cancer, although there is no proof of a relationship.

The city has been involved in the tanning business since 1987, and there are 10 tanning booths at eight city-owned pools.

It appeared the sun was setting on the city's involvement in the browning business in May when council decided not to renew a contract with Conalco Suntan and Health Equipment Leasing. But a new motion was pushed through executive committee in July to put out a new proposal call for tanning beds.

Ald. Judy Bethel, who has consistently supported Conalco, said the city can ensure that the equipment will be properly used and help minimize the risk.

Conalco president Alan Christiansen said tanning booths can benefit health if properly used, and he dismissed Reimer's arguments.

"If Jan Reimer was interested in closing the municipal airport, she could take a study on air travel," Christiansen said. "There's nothing healthy there either."

But there's no guarantee Christiansen will again operate tanning booths at city pools, which provided 30 percent of Conalco's revenue before the booths were shut down this year. The proposal first would have to be approved by council, and then Christiansen would have to win a proposal call.

Save your hide[2]

Stories by Bill Sass
Journal Staff Writer, Edmonton

To those sun lovers who can't wait to get out and tan their hides this summer, medical science has just one word.

Don't.

"People should not try to get a tan. It's almost criminal. It's wrong. It's just asking for trouble," says Edmonton dermatologist Orest Talpash, a spokesman for the Edmonton Dermatology Association.

To those folks who need a reason to forego their annual ritual of baste and bake, medical science has but two words:

Cancer and Wrinkles.

Talpash says the skin cancer rates used to be about one in 1,000 population. Now they are one in 100.

There are several types of skin cancer linked with prolonged exposure to the sun. The less severe types are more common and can be easily excised by a doctor. But in the medical dice game, a carefree sunbather can crap out and develop malignant melanoma, a particularly nasty form of skin cancer that can spread to other organs of the body (the skin by the way, is the largest organ of the body).

---

[1] *The Edmonton Journal* for the article "Mayor fails to block the 'sun,'" by Mike Sadava from December 6, 1990, page B3. Reprinted by permission of *The Edmonton Journal*.

[2] *The Edmonton Journal* for the article "Save your hide," by Bill Sass from May 28, 1992, page C9. Reprinted by permission of *The Edmonton Journal*.

According to 1989 statistics compiled by the Alberta Cancer Board, there were 146 new cases of malignant melanoma in Alberta that year in women and 114 in men. Thirty three of them died, nearly 11 percent.

Of the less severe skin cancers, 1,343 females and 1,669 males developed the disease. But less severe is relative—15 people still died.

Current "urban guess" sort of thinking puts the blame on the thinning ozone layer which filters out the cancer—and wrinkle-producing—ultraviolet rays of various sorts.

But Talpash says that link hasn't been established—and the increase in skin cancer rates may be more linked to many North Americans financial ability to run for the sun every winter—and the burgeoning sun tan parlour business.

"It (skin cancer) used to be pretty well limited to farmers, fishermen and golfers—now a lot more people are exposing a lot of skin to ultraviolet light."

The Alberta Cancer Board's director of epidemiology, Han Berkel, says it's a lifestyle thing.

"Look at the painting from the Dutch school—artists like Rubens. All the women in the paintings have white skin."

Pale skin used to be a status symbol, he said—the only ones who got tan were field hands and other labourers.

"Now it's a sign of wealth if you can afford a mid-winter break in the sun."

Dr. Caron Grin-Jorgensen, assistant professor of dermatology at the University of Connecticut has traced the social turning point to the mid 1920s when the French fashion designer Coco Chanel, the driving force behind fashion at the time, came back from a cruise sporting a tan.

Berkel said there are two schools of thought on what causes the most damage—whether it's the total number of hours exposed to the sun or infrequent, heavy exposures which occur on winter sun binges.

Which ever it is, he points out "there is no such thing as a healthy tan."

Prevention: It's In Our Hands[1]

Although the Alberta Cancer Board is working hard to improve the treatment of cancers, the fact is that many people are developing avoidable cancer. Statistics show that 50%–60% of the cancer cases and deaths in Alberta could be avoided if more attention were paid to the risk factors associated with cancer.

Cancer research has demonstrated that many types of cancer can be prevented. Each and every one of us can take steps to prevent cancer from developing in the first place.

Common Misconceptions

For the past few years we have been asking people what they think about cancer. The answers reveal there are still some misconceptions. For example:

Though most of us believe that the chances of being cured of cancer are better today than ever before, at least 50% think that:

- everything causes cancer.
- there isn't much a person can do to prevent cancer
- cancer is activated by a bruise or blow to the body.
- food additives are a major cause of cancer.
- All pollution causes cancer.

Less than half of those questioned believe that cancer risk is related to lifestyle choices.

Fact Not Fiction

Over the past decade research into the causes of cancer has brought about a better understanding of the different factors involved.

- We have more control over the major causes of cancer than we previously believed.

- 50%-60% of cancers are linked to lifestyle choices—the things we do and what we eat.

[1] "Prevention: It's In Our Hands," taken from *Cancer Prevention, Alberta Cancer Board 1989–90 Annual Report*, page 15. Reprinted by permission of the Alberta Cancer Board.

LRDC
Producer

Science 30
Student Module Booklet
Module 6

1995